THE TREASURY OF Fortification.

WHEREIN

That ART is made Intelligible to the Meaneſt Capacity; and the ſeveral METHODS of Fortifying, according to the late moſt Approved ENGINEERS in *Europe*, Explained.

With REFLECTIONS *thereupon*,

AND

Plain Directions how to Calculate the *Lines* and *Angles* of any Fortification, by the Tables of LOGARITHMS, SIGNS, TANGENTS, *&c.*

To which is added,

A New and Compendious METHOD, to Fortifie Irregular Places, compared with that generally made uſe of.

The Whole Illuſtrated with 37 *Figures.*

By JOHN BARKER, *Engineer.*

LONDON:
Printed for *A. Boſvile*, at the *Dyal* and *Bible* in *Fleet-ſtreet*; and *Jeffery Wale*, at the *Angel* in St. *Paul's* Church-yard, MDCCVII.

To His Excellency

JOHN,

Duke of *Marlborough*,
Marquiſs of Blandford, *Earl of*
Marlborough, *Baron* Churchill
of Sandridge *and* Aumouth;
Maſter General of the Ordnance,
Captain General of all Her Maje-
ſty's Forces, One of the Lords of
Her Majeſty's moſt Honourable
Privy-Council, Knight of the moſt
Noble Order of the Garter, Am-
baſſador Extraordinary and Pleni-
potentiary from Her Majeſty to the
United Provinces, *Prince of the*
Empire, and General *of the Con-*
federate Armies, &c.

S I R,

HAving often thought that the Want of ſome good Treatiſe of *Fortification*, in our own Language, a very great Miſfortune to the *Publick*, as being the occaſion of that great Ignorance amongſt us, in ſo Noble and Neceſſary an *Art*; which I could not but obſerve, after I had viewed and conſidered our Fortifications, both at *Home*, and in our Settlements *Abroad*. I have therefore made bold, moſt humbly to preſent your GRACE with theſe my poor Endeavours to promote that Art, to beg your Protection, and to ſpeak both my *Duty* and *Gratitude* to your GRACE, and my Ambition to render my ſelf ſerviceable to my *Country*; and alſo hereby to ſhew your GRACE, That thoſe vacant Hours, my late long and unhappy *Confinement*, when a Priſoner in *France*, gave me, were not altogether idly ſquander'd away:

This *Treatiſe*, being the Product of ſome part thereof, if it ſhall be ſo happy as to be crowned with your Grace's Approbation; who, beyond all Diſpute, is one of the beſt Judges in *Europe*, of any Performances of this kind, I ſhall eſteem my ſelf very happy, and my Time extreamly well ſpent; and it will be a ſufficient Encouragement to proceed to preſent your Grace with the other Treatiſe I have promis'd the Publick, with all poſſible ſpeed; ſince your Grace's *Approbation* is more than ſufficient to ſecure me and my Performances, from the Cenſure of the reſt of Mankind; whoſe vaſt Knowledge in all *Warlike Affairs*, and Wiſe Conduct are ſo obvious in thoſe many Glorious, and Unparallell'd *Victories*, which your

GRACE has obtain'd, and have render'd your *Name* a *Terrour* to that Haughty Monarch, who for ſo many Years has been both a Scourge and Terrour to *Europe*. Your Mighty and Glorious Actions have ſo far ſurpaſſed thoſe of the beſt *Commanders* the World ever yet produced, that when they ſhall be recited to future Ages, they will appear almoſt incredible. How much *Europe* in general, and this Kingdom in particular, *owes* to your GRACE, is beyond my Power to expreſs: For to your Prudent and Valiant Conduct under GOD, they owe their *Lives*, *Liberties*, *Eſtates*, and Every thing that Mankind eſteems moſt *Valuable*; which joyned with that admirable Sweetneſs of Temper, and prodigious ſhare of all other Vertues,

tues, which are daily conſpicuous in all your *Actions*, are not only very Surprizing to all, but juſtly render your GRACE the *Glory* of the preſent *Age*, as well as an *Exemplary Pattern* to all future; under the Beams of whoſe Radiant *Goodneſs*, I had been a very happy Man, through your GRACE's *Bounty*, had not my *Miſfortunes*, by being twice taken Priſoner by the Enemy, prevented the Good your GRACE deſigned me, who not only by their long detaining me, deprived me of the *Employments* your GRACE was pleaſed to honour me with, but alſo of thoſe great Preparations I was forc'd to make for my Subſiſtence and Accommodation, in a Place that afforded nothing but Wood and Brambles. But I intirely acquieſce in your GRACE's

Goodneſs, and ſhall be always ready, as in Duty bound, to teſtifie the profound Reſpect and Submiſſion with which I am,

Your GRACE'S

Moſt humble, and

moſt Obedient Servant,

John Barker.

THE

PREFACE.

THE *Imperfections of thoſe Treatiſes of Fortification, which have been either Wrote, or Tranſlated in our Language, made me often wiſh, that ſome able Pen would be ſo kind, as to favour his Country with ſuch a Treatiſe thereof, as might ſufficiently unfold the Principles of that Art, ſo as to render them obvious to the meaneſt Capacity. But none having been ſo kind as to do it, the* Fifteen *Months, in which I was laſt a Priſoner in* France, *having for my Diverſion, made a Collection of ſeveral Matters relating to* Fortification, *and ſeveral Curious* Experiments,

riments, *which one of the College of Jeſuits in* Renne, *the Place of my Confinement, was pleaſed to favour me with; moſt of which, I judg'd, might one time or other be ſerviceable in the Art of* War. *Upon my Return for* England, *finding the Employment that the Government was pleaſed to honour me with, diſpoſed of to another, to divert my vacant Hours, I collected therefrom, the following Treatiſe, not in the leaſt intending to expoſe it to the publick View, but to reſerve it for my own private uſe, and to pleaſure ſome particular Friends therewith; but upon the earneſt Solicitations of ſome Engineers, and ſeveral of my Mathematical Friends, I have, tho' not without great Reluctancy, adventuned to publiſh it in this ſo Critical an Age, wherein, I am ſenſible, there are not wanting ſuch as will condemn* *what they underſtand not: If this Book happens into the Hand of ſuch, all that I ſhall deſire of them, is to conſider, It is much eaſier to find Fault, than to do better, and therefore to ceaſe Cenſuring, till they have favoured the Publick with a more compleat Treatiſe of their own. As for the Judicious, I perſwade my ſelf, they will candidly accept of theſe my Endeavours to promote ſo uſeful and neceſſary an Art, and will not carp at the meanneſs of the Style, it having been my utmoſt Endeavour to render my Self intelligible to the meaneſt Reader; and I cannot but hope, that this my poor Eſſay will rouſe ſome Ingenious Spirits of our Nation, to make ſome farther Progreſs in the Advancement of this* Art, *and that I ſhall ſee our Nation as well skill'd therein, and as diligent to preſerve what they have, as the* French, *or any other*

Nation whatſoever, and not to depend ſo intirely on a Fleet, which it is impoſſible, ſhould well defend from the Inſults of an Enemy, ſuch vaſt Territories as thoſe of the English *Mo*narchy *are, and no longer be contented with Forts made of Prickle Pears, or ſuch Pigeon-Houſes, and Mince-Pies, as I have ſeen in ſeveral parts, which have neither Capacity to hold a Garriſon, nor, which is worſe, any good* Defence, *nor for the future admit in our beſt and largeſt Fortifications, any of thoſe Toys and Trifles, which I have ſufficiently ſhewn, are very defective; for I am fully perſwaded, that if inquiry be made, why our* Settlements *abroad, are no better Peopled, and why ſo many of late, have drawn their Effects from thence, the chief reaſon, will be found to be want of* Forts *ſufficient to defend them from the* Inſults *of the Enemy.*

But it will be expected I ſhould ſay ſomething of the Matter *contained in this Book, which I have the Vanity to perſwade my ſelf, is ſuch as will ſufficiently recommend it ſelf, and how juſtly and well I have anſwered the end of Writing it,* viz. *To* inſtruct *the Unlearned, I leave the Reader to judge, and I am perſwaded, they who have made any conſiderable Progreſs in the Art of* Fortification, *will not think their Time loſt in peruſing it; for I have not only therein explained all the* Terms *and* Principles *of this Art, in ſo plain and familiar a manner, as I verily believe, will give the* meaneſt *Reader a ſufficient Knowledge, not only to* Fortifie *any manner of place, however ſituated, but alſo to diſcover the* Perfections, *and* Imperfections *of all ſorts of Works whatſoever, giving the Idea of the moſt approved Engineers of*

Europe, *with the Conſtruction of their ſeveral* Methods *of Fortification, and* Remarks *on each of them, together, with the* Method *how to Calculate the ſeveral* Lines *and* Angles *of any Fortreſs, by the Tables of* Logarithms, *Artificial* Sines, Tangents, *and* Secants ; *with Tables ready calculated of four ſeveral Methods : To which I have added, A* New *and* Compendious *Method, to Fortifie* Irregular *Places ; and compared it with that generally made uſe of ; with the Conſtruction of Citadels, Field-Works, and alſo the manner of Building a Fort,* &c. *In a Word, here the Reader is preſented with the whole Art of* Fortification, *in as plain and familiar a manner, as can be expected.*

Here I beg leave to take notice of two very great Errors, ſince I find the one has diſcouraged ſome from Studying

Studying this Art, and the other has been made uſe of to impoſe upon Mankind.

The firſt of which is an Error I find entertain'd even amongſt ſome of the Gentlemen of the Army, viz: *That a Perſon can never underſtand* Fortification, *till he has been at ſeveral Sieges; but let not that falſe Notion diſcourage any Perſon; for I do affirm, A Perſon may be at an hundred* Sieges, *and aſſiſt at the building as many* Fortreſſes, *and ſee all the Fortifications in* Europe, *provided they were all good, and after all, underſtand nothing to any purpoſe of this Art, provided he doth not firſt underſtand well the* Principles *thereof: If it was otherwiſe, how comes it to paſs, that every Stone-cutter is not a good Architecture, every Labourer a good Carpenter, Joyner,* &c. *ſince they are things that are both in them.*

themſelves leſs difficult, and all their Performances *are govern'd by Rules, moſt ſimple and eaſie to be comprehended by the* meaneſt *Capacity, ſince they have the advantage of ſeeing them daily practiſed: Whereas the Art of* Fortification *is founded on Principles of another kind, which require both Time and Application to underſtand well, and the various manners of the Application, of which Rules or Principles, in the different Methods of Fortifying of Places, renders it, beyond all diſpute, impoſſible for any Perſon, of how great Abilities ſoever, to learn it by any other* Method, *than what is ordinarily made uſe of in learning all other parts of the* Mathematicks; *and for ſuch as would introduce only a Field* Education, *it may be to ſhelter their own, or others Ignorance; much good may it do them. But if theſe Perſons only mean,*

mean, that a Perſon cannot learn ſo well how to Attack and Defend a Place, till he has been at ſeveral Seiges; I confeſs, in that reſpect, a Perſon is better inform'd in the Field, than by any other Method. *But that can by no means be called* Fortification; *and therefore I have deſigned that* Subject *for a particular* Treatiſe; *wherein I ſhall not only treat of the ſeveral* Methods *of Attacking and defending a Place, the making of* Mines, Countermines, Batteries, Fire-works, *&c. but alſo give ſome Curious Experiments, and Obſervations of ſeveral* Ingenious Perſons, *concerning the making of* Powder, Ordnance, Mortars, *&c. and ſhew the Uſe thereof, according to the laſt and beſt eſteemed* Maxims.

The ſecond is an Error, by which I find ſeveral moſt Ingenious Perſons *are impoſed upon,* viz. *Taking it for granted, That he that can but draw a* Fort *well, muſt needs be a good* Engineer, *without any regard to his other Qualifications: I muſt confeſs, that is a very pretty Qualification, and renders an* Engineer's *Draughts very agreeable to the Eye; but it can by no means be thought ſufficient to make an* Artiſt; *for if ſo, moſt* Painters *are conſequently* Engineers, *ſince there is none of them, that are Artiſts in their Profeſſion, but can draw the Draught of a* Fortreſs *very lively, tho' he underſtands nothing at all to any Purpoſe of this* Art: *But if a Perſon really underſtands the* Art, *tho' his Draughts are not ſo curiouſly Imbelliſhed and ſet off, as ſome* Ignorant Pretenders *may be, who have nothing elſe but* *ſuch Gaudy Appearances, attended with a good Aſſurance, which is the* Inſeparable Companion *of* Ignorance, *to impoſe upon* Mankind *a Belief, that they underſtand, what upon Examination they will be found ignorant of; yet they being moſt exact, and ſuch as he is able to demonſtrate to be ſo, will be much more acceptable to the knowing part of* Mankind.

All that I ſhall add, is my hearty Wiſhes, That the Endeavours *of thoſe that deſire the* Knowledge *of this* Art, *may be ſucceſsful; and if to any ſuch, I can be ſerviceable in explaining any Matter in relation thereto, I ſhall be very free to do it; I having no other Ambition, than to render my ſelf* Serviceable *to my* Country, *by the Advancement of ſo Uſeful and Neceſſary an* Art: *Which, if by this* Book, *or any* *other* Method, *I ſhall be ſo happy to do, I have my Ends, who am a Well-Wiſher to all* Ingenious Artiſts.

J. Barker.

THE

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Memorandum, That the Epaul, or Orillon of the firſt Figure in Fortification, ſhould have been made round as in Monſieur *Vauban*'s Method.

That ſome of the Wooden Cuts are omitted to be numbred, yet being placed in the Pages to which they belong, can be no Inconvenience.

SOME

GEOMETRICAL PROBLEMS,

Neceſſary to be underſtood.

PROBLEM I.

To draw a Strait Line upon the Ground.

IF it be required to draw a Strait Line from A to B.

First place a Picket at A, alſo place another at B, and placing your ſelf at A, let another Perſon carry a Picket to C, and there let him move it to and fro;

till, when laying your Eye over the Picket A, directing your ſight to the Picket at B, it will cover the Picket at B, there let him faſten it; ſo will a Cord faſtned from A to C, and from C to B, mark out a Strait Line from A to B, required.

After the ſame Method, when you have neither Line nor Chain long enough to mark it out at twice, you may place three or four Pickets, as there ſhall be occaſion.

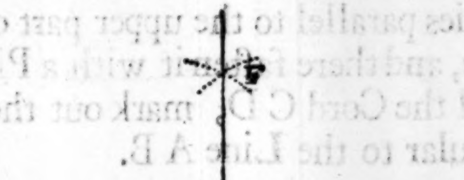
PROB. 2.

To Erect a Perpendicular, either on Paper, or on the Ground, from any part of a Line given.

SUppoſe it be required from the point C, in the Line A B, to erect a Perpendicular.

Firſt on Paper.

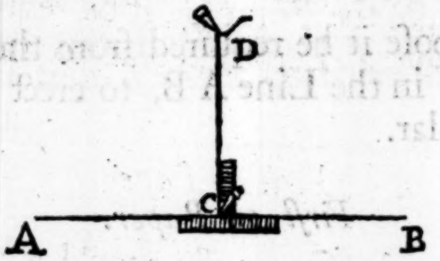
With your Compaſſes open'd to any convenient diſtance, from C, make the



two marks at D and E, then opening your Compaſſes to any convenient diſtance wider, from D and E ſweep the two Arches, interſecting each other in the Point F, and from C by F, draw a Line which ſhall be Perpendicular to A B.

On the Ground.

First place a Picket at C, and thereto faſten a Cord, then place the Square on



the Line A B, to the Point C, and let another take the Cord to D (or at any convenient diſtance) and move it to and fro, till it lies parallel to the upper part of the Square, and there faſten it with a Picket; ſo ſhall the Cord C D, mark out the Perpendicular to the Line A B.

PROB.

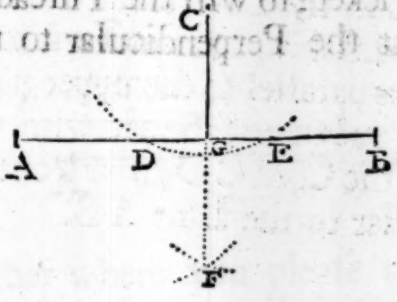
PROB. 3.

From any Point above a Line, to draw a Perpendicular either upon Paper, or the Ground.

IF from the Point C, it be required to draw a Perpendicular to the Line A B.

Firſt on Paper.

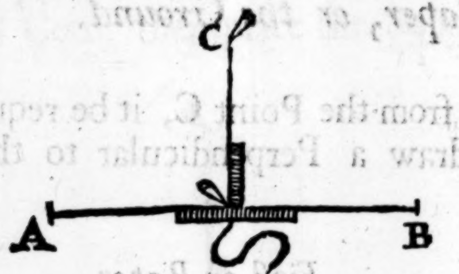
With the Compaſſes open'd to any convenient diſtance, from C ſweep the Circle, cutting the Line A B into the Point D and E, and from D and E ſweep the Arches, interſecting each other in the Point



Point F; then laying a Ruler by C and F, draw the Perpendicular C G.

Secondly, On the Ground.

Faſten your Cord with a Picket on the Point C, and move your Square and



Thread along the Line A B, till the Thread extended lies parallel to the upper part of the Square, which then faſten with a Picket; ſo will the Thread or Cord mark out the Perpendicular to the Line A B.

PROB.

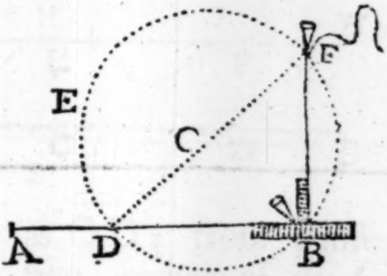
PROB. 4.

To erect a Perpendicular on the End of a Line.

IF it be propoſed to draw a Perpendicular from the End B, of the Line A B.

Firſt upon Paper.

Open your Compaſſes at diſcretion, and placing one Foot in the Point B, carry the other where you pleaſe towards the other end A, for example in C; then with the Point of your Compaſs in C, ſweep the Circle B D E F; which being done, from the Point of Interſection D, draw



by the Center of the Circle E, the Diameter D C F; then if from the Section F, you draw the Line F B, it will be the Perpendicular required.

On the Ground.

Faſten a Cord to a Picket on the Point B, where alſo place your Square, the lower part being parallel to the Cord A B, and let another Perſon at F, move the Cord to and fro, till the Cord extended be parallel to the ſide of the upper part of the Square, and then let him faſten it with a Picket; ſo will the Cord B F mark out the Perpendicular.

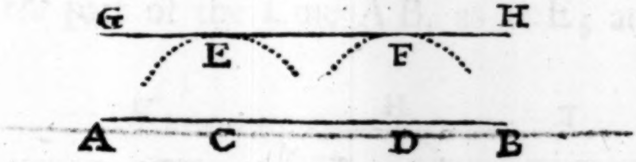
PROB. 5.

To draw a Line parallel to another Line.

LEt it be required to draw a Line Parallel to the Line A B.

Firſt, Upon Paper.

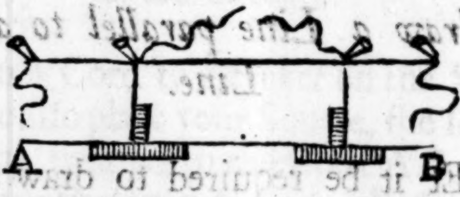
Open your Compaſſes at diſcretion, making choice of any two Points in the



Line A B, as C D; from thoſe Points ſweep the two Arches of the Circle E and F; then if you draw a Line ſo that it touches thoſe two Arches, as the Line G H, it will be parallel to the Line A B.

Secondly, On the Ground.

Draw two Perpendiculars on the Line A B, with the Square, as has been before



ſhewn, of an equal length, and draw a Line by the extremity of thoſe two Perpendiculars, and it will be parallel to the Line A B.

PROB.

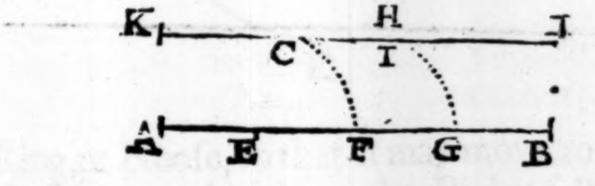
Prob. 6.

To draw a Line parallel to any other Line which ſhall paſs by a given Point.

IF it be required to draw a Line parallel to the Line A B, which ſhall paſs by the Point C.

Firſt, On Paper.

Place your Compaſſes in ſome convenient part of the Line A B, as at E; and with the Compaſſes opened to the diſtance E C, ſweep the Arch C F, and with the ſame diſtance from F, ſweep the Arch H G; then ſet off the diſtance C F, from G to I; then if from the Point C, by the Point



Point I, you draw the Line K L, it will be parallel to the Line A B.

Secondly, On the Ground.

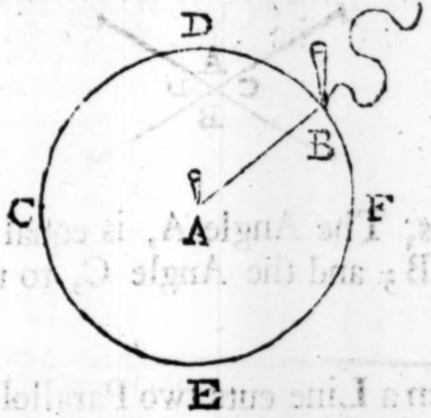
Firſt, From C, by *Problem the Third*, draw a Perpendicular on the Line A B, and at any diſtance therefrom erect another Perpendicular by *Problem the Second*, on the ſaid Line A B, equal in length to the former ; then a Line drawn by the extremity of theſe two Perpendiculars, ſhall be parallel to the Line A B.

PROB.

PROB. 7.

To deſcribe a Circle on the Ground.

ON the Center, as **A**, faſten a Picket, and faſten a Cord either by an Iron



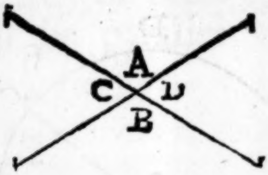
Ring, or Nooſe, ſo that it may move round the Picket, and with another Picket faſtned to the Cord at the diſtance you will have the Diameter of the Circle, as A B, deſcribe the Circle BDCEF, after which Method may be deſcribed any Arch or part of a Circle on the Ground, as well as with Compaſſes upon Paper.

PROB.

PROB. 8.

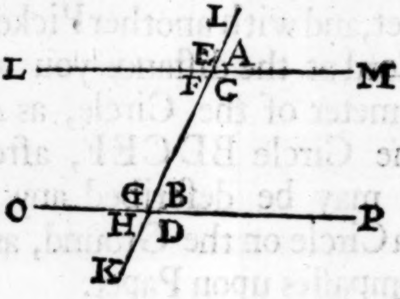
Maxims of Angles.

WHen that two Lines croſs each other, the oppoſite Angles are equal.



Thus, The Angle A, is equal to the Angle B; and the Angle C, to the Angle D.

When a Line cuts two Parallel Lines, as doth the Line I K, which cuts the two



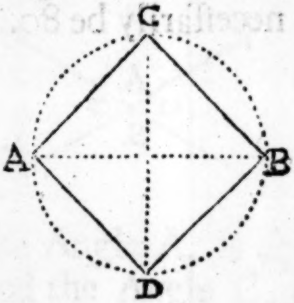
Parallel Lines L M and O P, the Alternative or Interchangable Angles, are equal, as A and B, or E and G, or C and D, or F and H: Moreover, the Alternate Angles are equal, as F and B, or C and G: Alſo the Interiour Angles on the ſame ſide, are equal to two Right Angles, or 180 Degrees. Thus the Angles B and C, are together 180 Degrees; as alſo are the Angles F and G, in ſuch ſort, that if the Angle C is 100 Degrees, the Angle B, will neceſſarily be 80.

PROB.

Prob. 9.

To Inſcribe a Square in a Circle.

Draw the Diameter A B, which cut at Right Angles, or Perpendicularly, by the Diameter C D; then draw the Lines A C, A D, C B, and D B, and you will have the inſcribed Square A C B D.

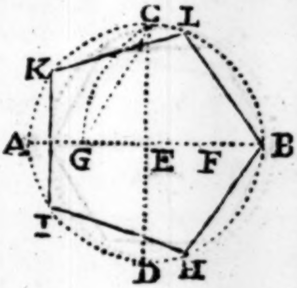


Prob.

PROB. 10.

To Inſcribe a Pentagon, or a Figure of five equal Sides, in a Circle.

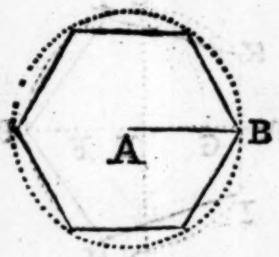
DRaw the Diameter A B, and the Perpendicular Diameter C D, divide the Radius E B, into two equal parts in the Point F; then with one Foot of your Compaſſes in F, with the diſtance F C, ſweep the Arch C G, ſo will the diſtance C G divide the Circle into five equal parts in the Points B L K I H; then there is no more to be done, but to join the ſaid five Points by the Cords or Strait Lines, to finiſh the Pentagon.



PROB. 11.

To Inſcribe in a Circle a Hexagon, or a Figure of ſix equal Sides.

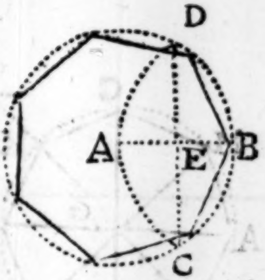
DRaw the Radius, or Semi-diameter A B, and that diſtance will divide the Circumference of the Circle into ſix equal Parts.



PROB. 12.

To Inſcribe in a Circle a Heptagon, or a Figure of ſeven equal Sides.

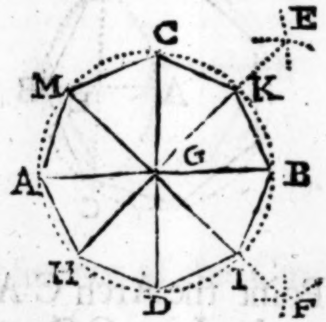
DRaw the Radius A B, and placing one Point of your Compaſſes on B, and with the Diſtance B A, ſweep with the other Point the Arch C A D; afterwards draw the Line C D, the half of which, C E or D E will divide the Circle into Seven equal Parts.



PROB. 13.

To Inſcribe an Octagon, or a Figure of Eight equal Sides.

DRaw the Diameter A B, and the Perpendicular Diameter C D, as we have before ſhewn, in deſcribing the

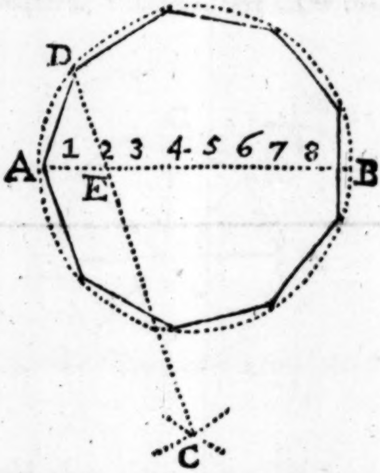


Square, and the Circle will be divided into four equal Parts, which by dividing each Arch into two equal Parts, will be divided into Eight equal Parts; which may be done thus: From B and C, ſweep the two Arches Interſecting each other in the Point E; and from the Section E, by the Center G, draw the Diameter K H; afterwards from the Points B and D, ſweep the two Arches, which interſect each other in F; then if from the Point F, paſſing by the Center G, you draw the Diameter I M, the Circle ſhall be divided into Eight equal Parts, and there is nothing more to be done, then to draw the Eight Sides.

Prob. 14.

To Inſcribe an Enneagone, or Figure of Nine equal Sides.

DIvide the Diameter A B, into Nine equal Parts; afterwards open the

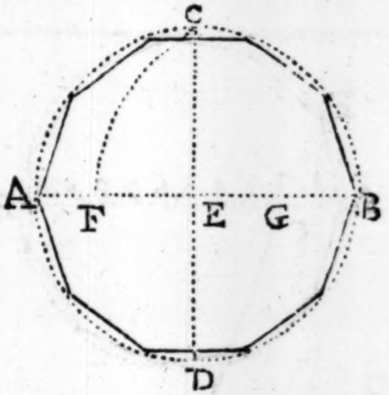


Compaſſes to all the Length of the Diameter A B; and from the Points A and B, ſweep the two Arches interſecting each other in C; then from C, by the ſecond Diviſion of the Diameter E, draw the Line C E D, and the Cord A D, ſhall divide the Circle into Nine equal Parts.

PROB. 15.

To Inſcribe a Decagon, or Figure of Ten equal Sides.

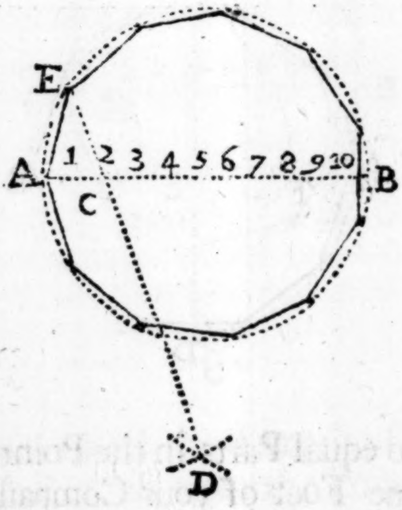
DRaw, in the firſt place, the Diameters of A B, and C D, at Right Angles at E, and divide the Radius E B, into two equal Parts in the Point G; and with one Foot of your Compaſſes in G, with the diſtance G C, ſweep the Arch C F; ſo ſhall the diſtance F E, divide the Circle into Ten equal Parts.



Prob. 16.

To Inſcribe an Endecagon, or Figure of Eleven equal Sides.

Divide the Diameter into Eleven equal Parts; afterwards, as in the Enneagon, open the Compaſſes to the

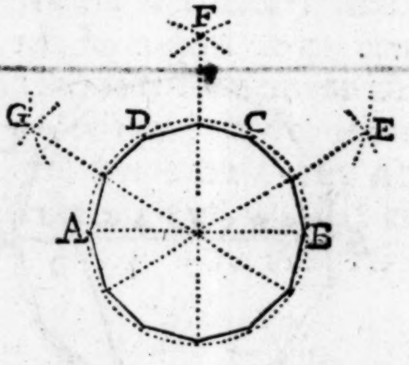


whole Length of the Diameter A B; and with that diſtance, from the Points A and B, ſweep the two Arches interſecting each other in the Point D; and from D, through the ſecond Diviſion of the Diameter A B, draw the Line D C E; ſo ſhall the Cord A E, divide the Circle into Eleven equal Parts.

PROB. 17.

To Inſcribe a Dodecagon, or Figure of Twelve equal Sides.

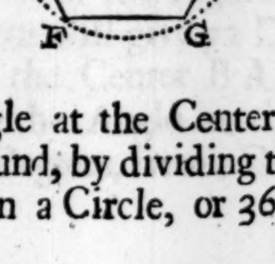
AFter having divided the Circle into Six equal Parts, as in the Hexagon, divide the three Arches, B C, C D, and D A, into two equal Parts, and drawing from the Sections E F G, the Diameters, as was ſhewn in the Octagon; ſo will you have the Circle divided into Twelve equal Parts.



Prob. 18.

To find the Angles of a Polygon.

THE Sides of a Polygon being equal, all the Angles at the Center conſequently muſt be equal; and alſo all the Angles of the Polygon muſt be equal; becauſe all the Lines drawn from the Center to each Angle of the Polygon, are equal to the Radius of the circumſcribed Circle, which cuts the Angle of the Polygon into Two equal Parts, making with each ſide an Iſoſcele, or Equilateral Triangle, as A B C.



The Angle at the Center B A C, or C A D, is found, by dividing the Number of Degrees in a Circle, or 360 Degrees, by the Number of Sides in the Polygon.

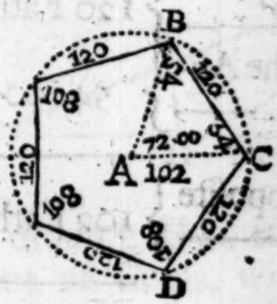
For Example.

The Polygon B C D G F E, being a Hexagon, or a Figure of Six equal Sides, if you divide 360 by 6, the Quotient will give 60 Degrees for the Angle at the Center B A C: Then becauſe the three Angles of a Triangle, are equal to a Demicircle, or 180 Degrees: Therefore, if you ſubtract the Angle at the Center B A C, or 60 Degrees, from a Demicircle, or 180 Degrees, the Remainder will give 120 Degrees for the Sum of the two Angles A B C, and A C B; or the Angle at the Polygon B C D or C B E; and becauſe the Angles A B C, and A C B, are equal; therefore the half of 120 Degrees, will give 60 Degrees for the Angle A B C, or A C B.

PROB. 19.

To find the Radius of a Circle, that will form a Polygon, whoſe Sides ſhall be of any Length required.

IF it be required to find the Radius of a Circle, to form a Pentagon, or a Figure of Five equal Sides, whoſe Sides ſhall each be 120 Fathoms.



Firſt, Find the Angle at the Center B A C, by dividing 360 Degrees by the Number of Sides in the Figure, or Five, and the Quotient will give 72 Degrees for the Angle at the Center B A C; then by ſubtracting the Angle at the Center B A C, or 72 Degrees, from a Demicircle, or 180 Degrees, the Remainder will give 108 Degrees for the Angle at the Polygon B C D, the half of which will give 54 Degrees for each of the Angles A B C, and A C B.

So have you in the Triangle A B C, all the Angles, and the Side B C, given, to find the Side A C, or Radius of the Circle, by the following Proportion.

	° ′ Co. Ar.
As (s) of the Angle B A C ——	72 : 00—0.021794
Is to the Oppoſite Side B C——	120 Fath.-1.079181
So is (s) of the Angle A B C ——	54 : 00—9.907958
To the Oppoſite Side A C——	102 Fath.-1.008933

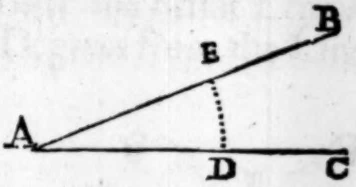
So that if with 102, from your Scale of equal Parts, you deſcribe a Circle, 120, from the ſame Scale, will divide that Circle into Five equal Parts.

PROB. 20.

To meaſure an Angle, either upon Paper, or on the Ground.

Firſt, Upon Paper.

WIth 60 Degrees taken from your Line of Cords, with one Foot in the Angular Point A, ſweep the Arch



DE, which diſtance DE, meaſured on the ſame Line of Cords, will give 23 Degrees for the Meaſure of the Angle BAC.

Otherwiſe it may be meaſured with a Protractor, by applying the Center thereof to the Angles Point A, and its Diameter parallel to AC, and the Degrees on the Circular Arch will ſhew 23 Degrees to be the Meaſure of the Angle B A C.

Secondly, On the Ground.

Place your Inſtrument, be it a Circle, Semicircle, or Quadrant, on the Ground, with its Center upon the Point A; and its Radius parallel to the Line A C, with its Sights directed to B, or a Line faſtued to a Picket at A, extended to B, will give on the Inſtrument, 23 Degrees for the Meaſure of the Angle B A C.

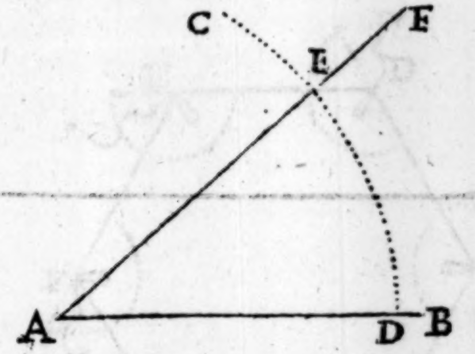
PROB. 21.

To lay down an Angle given, either upon Paper, or on the Ground.

IF it be required at A, to make an Angle of 40 Degrees.

Firſt, Upon Paper.

Draw firſt the Strait Line A B; then with 60 Degrees from the Line of Cords,



with one Foot in A, ſweep the Arch C D; then take 40 Degrees from the ſame Line of Cords, and place it from D to E, and from A by E, draw the Line ~~A E F, ſo ſhall the Angle B A F, be 40~~ Degrees.

Secondly, On the Ground

Firſt, From A, draw the Strait Line A B; then place the Center of your Inſtrument at A, ſo as the Semidiameter, or Radius, lies parallel to the Line A B, and with a Cord, or String faſtned to a Picket at A, and extended towards F, that it will cut 40 Degrees on the Inſtrument, will mark out the Line A F, making with the Line A B, an Angle of 40 Degrees.

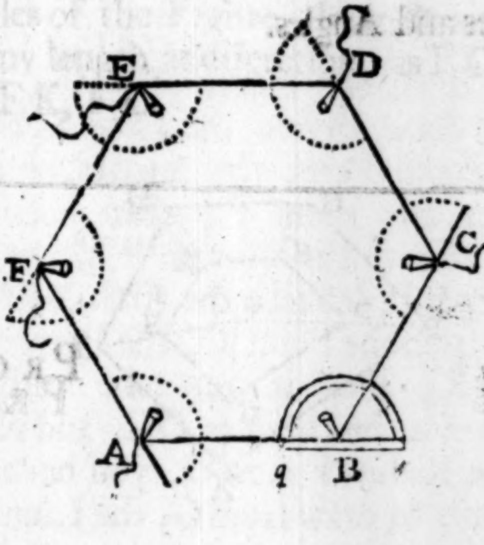
PROB.

Prob. 22.

To deſcribe a Polygon round a Place where the Center is occupied.

IF it was required to draw a Hexagon round a Place, whoſe Sides ſhall each be 120 Fathoms.

The Angle at the Polygon of a Hexagon, you will find by *Prob.* 17. to be 120 Degrees.



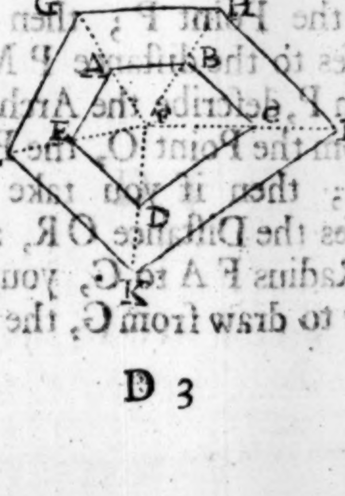
Firſt, Draw the Line A B of 120 Fathoms, placing a Picket or Mark at A; then place your Inſtrument at B, ſo that the Radius of the Inſtrument B *q* lies exactly parallel upon the Line A B, and with the Sights, or a Cord faſten'd to a Picket at B, extended toward C, till it cuts 120 Degrees on the Inſtrument, mark the Line B C of 120 Fathoms; then move your Inſtrument to C, placing the Center on C, and the Radius of the Inſtrument exactly parallel on the Line C B, with a Cord faſtned to the Picket at C, and extended towards D, till it cuts 120 Degrees on the Inſtrument, mark out the Line C D of 120 Fathoms: After the ſame manner lay down the reſt of the Sides and Angles.

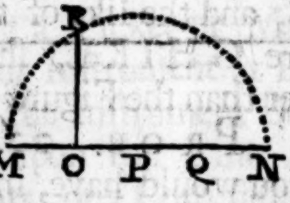
PROB. 25.

To augment or diminiſh any Polygon, whether Regular or Irregular, as one will.

LET it be propoſed to augment the Irregular Polygon A B C D E, three times larger.

Chuſe a Point for a Center at diſcretion, as F, and from thence to the ſeveral Angles of the Figure, draw Strait Lines of any length at diſcretion, as F G, F H, F I, F K, F L.





Then make choice of any one of the Radius's of the Figure,

For Example,

F A, and place that diſtance on a Strait Line, as M N, from M to O; and becauſe you will have your Polygon three times as large as the firſt, place the ſame diſtance on the ſame Line from O, three times, *viz.* from O to P, from P to Q, and from Q to N, to the end that O N be three times the length of M O; which being done, divide the Line M N into Two equal Parts, the middle of which here is the Point P; then open your Compaſſes to the diſtance P M, or P N; and from P, deſcribe the Arch MRN, and draw from the Point O, the Perpendicular O R; then if you take with your Compaſſes the Diſtance O R, and place it on the Radius F A to G, you have after that only to draw from G, the Line G H, parallel to A B, and from H, H I parallel to B C, and the like of the reſt ; and the Figure G H I K L, ſhall be there times larger than the Figure A B C D E.

But if you would have, inſtead of augmenting, diminiſhed the Figure ABCDE, you muſt do it after the ſame manner, only inſtead of adding the Diſtance to the Radius F A, you muſt have cut the ſame Diſtance from it, by placing it within the Figure.

A
Table of Angles,
Comprifed between
Two Sides of Thirty Feet.

Baſe.		*Angles.*		*Baſe.*		*Angles.*	
Fe.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
	0		00	2	00	3	49
	2		19	2	02	4	68
	4		38	2	04	4	28
	6		57	2	06	4	47
	8	1	08	2	08	5	06
	10	1	36	2	10	5	25
1	00	1	55	3	00	5	44
1	02	2	14	3	02	6	03
1	04	2	33	3	04	6	22
1	06	2	52	3	06	6	41
1	08	3	11	3	08	7	00
1	10	3	30	3	10	7	20

A Table of Angles made by Two Sides of 30 *Feet.*

Base.		*Angles.*		*Base.*		*Angles.*	
Fe.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
4	00	7	39	8	00	15	20
4	02	7	58	8	02	15	39
4	04	8	17	8	04	15	58
4	06	8	36	8	06	16	18
4	08	8	55	8	08	16	37
4	10	9	14	8	10	16	56
5	00	9	34	9	00	17	15
5	02	9	53	9	02	17	34
5	04	10	12	9	04	17	54
5	06	10	31	9	06	18	13
5	08	10	50	9	08	18	32
5	10	11	09	9	10	18	52
6	00	11	29	10	00	19	11
6	02	11	48	10	02	19	30
6	04	12	08	10	04	19	50
6	06	12	27	10	06	20	19
6	08	12	46	10	08	20	29
6	10	13	05	10	10	20	48
7	00	13	24	11	00	21	08
7	02	13	43	11	02	21	27
7	04	14	02	11	04	21	46
7	06	14	22	11	06	22	06
7	08	14	41	11	08	22	25
7	10	15	00	11	10	22	45

A Table of Angles made by Two Sides of 30 Feet.

Base.		*Angles.*		*Base.*		*Angles.*	
Fe.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
12	00	23	05	16	00	30	56
12	02	23	24	16	02	31	16
12	04	23	44	16	04	31	36
12	06	24	03	16	06	31	56
12	08	24	32	16	08	32	16
12	10	24	42	16	10	32	35
13	00	25	01	17	00	32	55
13	02	25	21	17	02	33	15
13	04	25	41	17	04	33	35
13	06	26	01	17	06	33	55
13	08	26	20	17	08	34	15
13	10	26	40	17	10	34	35
14	00	26	59	18	00	34	55
14	02	27	18	18	02	35	15
14	04	27	38	18	04	35	35
14	06	27	58	18	06	35	55
14	08	28	18	18	08	36	15
14	10	28	38	18	10	36	35
15	00	28	57	19	00	36	55
15	02	29	17	19	02	37	15
15	04	29	37	19	04	37	36
15	06	29	56	19	06	37	56
15	08	30	16	19	08	38	16
15	10	30	36	19	10	38	36

A Table of Angles made by Two Sidss of 20 Feet.

Base.		*Angles.*		*Base.*		*Angles.*	
Fe.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
20	00	38	56	24	00	47	09
20	02	39	17	24	02	47	30
20	04	39	38	24	04	47	51
20	06	39	58	24	06	48	12
20	08	40	18	24	08	48	33
20	10	40	38	24	10	48	54
21	00	40	59	25	00	49	15
21	02	41	19	25	02	49	36
21	04	41	40	25	04	49	57
21	06	42	00	25	06	50	18
21	08	42	20	25	08	50	39
21	10	42	40	25	10	51	00
22	00	43	01	26	00	51	21
22	02	43	22	26	02	51	42
22	04	43	42	26	04	52	03
22	06	44	03	26	06	52	24
22	08	44	24	26	08	52	46
22	10	44	44	26	10	53	08
23	00	45	05	27	00	53	29
23	02	45	26	27	02	53	51
23	04	45	46	27	04	54	12
23	06	46	07	27	06	54	34
23	08	46	28	27	08	54	55
23	10	46	48	27	10	51	16

A Table of Angles made by Two Sides of 30 Feet.

Baſe.		*Angles.*		*Baſe.*		*Angles.*	
Fe.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
28	00	55	38	32	00	64	28
28	02	56	00	32	02	64	50
28	04	56	22	32	04	65	13
28	06	56	43	32	06	65	36
28	08	57	05	32	08	65	58
28	10	57	26	32	10	66	21
29	00	57	48	33	00	66	44
29	02	58	10	33	02	67	07
29	04	58	32	33	04	67	30
29	06	58	54	33	06	67	53
29	08	59	16	33	08	68	16
29	10	59	38	33	10	68	39
30	00	60	00	34	00	69	02
30	02	60	22	34	02	69	25
30	04	60	44	34	04	69	48
30	06	61	06	34	06	70	12
30	08	61	28	34	08	70	35
30	10	61	50	34	10	70	59
31	00	62	13	35	00	71	22
31	02	62	35	35	02	71	46
31	04	62	58	35	04	72	10
31	06	63	20	35	06	72	33
31	08	63	43	35	08	72	56
31	10	64	05	35	10	73	20

A Table of Angles made by Two Sides of 30 Feet.

Baſe.		*Angles.*		*Baſe.*		*Angles.*	
Fe.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
36	00	73	44	40	00	83	37
36	02	74	08	40	02	84	03
36	04	74	32	40	04	84	29
36	06	74	56	40	06	84	54
36	08	75	20	40	08	85	20
36	10	75	44	40	10	85	46
37	00	76	09	41	00	86	13
37	02	76	33	41	02	86	39
37	04	76	57	41	04	87	05
37	06	77	22	41	06	87	32
37	08	77	46	41	08	87	58
37	10	78	09	41	10	88	25
38	00	78	35	42	00	88	51
38	02	79	00	42	02	89	18
38	04	79	25	42	04	89	45
38	06	79	50	42	06	90	12
38	08	80	15	42	08	90	39
38	10	80	40	42	10	91	06
39	00	81	05	43	00	91	33
39	02	81	30	43	02	92	01
39	04	81	55	43	04	92	29
39	06	82	20	43	06	92	56
39	08	82	46	43	08	93	24
39	10	83	12	43	10	93	52

A Table of Angles made by Two Sides of 30 Feet.

Baſe.		*Angles.*		*Baſe.*		*Angles.*	
Ft.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
44	00	94	20	48	00	106	16
44	02	94	48	48	02	106	48
44	04	95	16	48	04	107	20
44	06	95	45	48	06	107	52
44	08	96	13	48	08	108	25
44	10	96	42	48	10	108	57
45	00	97	11	49	00	109	30
45	02	97	40	49	02	110	04
45	04	98	09	49	04	110	37
45	06	98	38	49	06	111	11
45	08	99	08	49	08	111	44
45	10	99	37	49	10	112	18
46	00	100	06	50	00	112	53
46	02	100	36	50	02	113	28
46	04	101	06	50	04	114	03
46	06	101	36	50	06	114	38
46	08	102	07	50	08	115	14
46	10	102	37	50	10	115	49
47	00	103	08	51	00	116	26
47	02	103	31	51	02	117	02
47	04	104	10	51	04	117	39
47	06	104	41	51	06	118	16
47	08	105	12	51	08	118	53
47	10	105	44	51	10	119	31

A Table of Angles made by Two Sides of 30 Feet.							
Baſe.		*Angles.*		*Baſe.*		*Angles.*	
Fe.	*In.*	*Deg.*	*M.*	*Fe.*	*In.*	*Deg.*	*M.*
52	00	120	09	56	00	137	57
52	02	120	47	56	02	138	49
52	04	121	26	56	04	139	44
52	06	122	06	56	06	140	40
52	08	122	45	56	08	141	38
52	10	123	25	56	10	142	36
53	00	124	06	57	00	143	36
53	02	124	47	57	02	144	39
53	04	125	28	57	04	145	43
53	06	126	10	57	06	146	48
53	08	126	52	57	08	147	57
53	10	127	35	57	10	149	08
54	00	128	19	58	00	150	20
54	02	129	03	58	02	151	36
54	04	129	48	58	04	152	55
54	06	130	33	58	06	154	19
54	08	131	19	58	08	155	48
54	10	132	06	58	10	157	22
55	00	132	53	59	00	159	03
55	02	133	44	59	02	160	53
55	04	134	30	59	04	162	54
55	06	145	20	59	06	165	12
55	08	136	11	59	08	167	48
55	10	137	03	59	10	171	28
				60		180	00

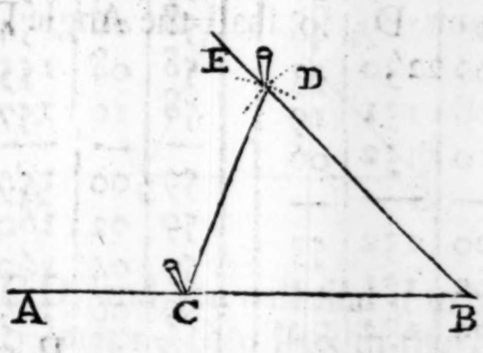
Prob. 24.

To lay down an Angle, either upon Paper, or on the Ground, by the aforegoing Tables.

SUppoſe it was required to lay down an Angle of 43 Degrees, and 22 Minutes.

Firſt, On Paper.

Firſt, Search in the Table in the Colume intitled Angles, for 43 Deg. 22 Min. and againſt it on the Left Hand, you will find the Baſe to be 22 Feet 2 Inches.



Firſt,

Firſt, On the given Line A B, place 30 Feet from B to C; then with your Compaſſes to the Diſtance of 22 Feet 2 Inches, with one Foot in C, ſweep an Arch; then with your Compaſſes open'd to 30 Feet, with one Foot in B, ſweep another Arch interſecting the former in the Point D; then from B by the Point, if you draw the Line E D B, the Angle A B E ſhall be 43 Degrees 22 Minutes.

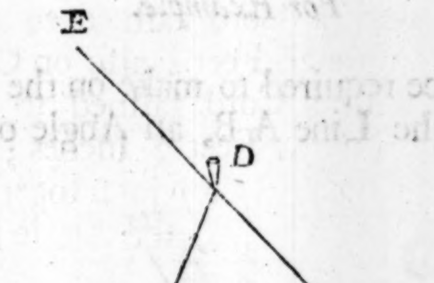
Secondly, On the Ground.

On the given Line A B, place 30 Feet from B to C, and on the Point B faſten a Picket, with a Cord faſtned to it, on which meaſure 30 Feet; alſo on C place a Picket with a Cord faſtned to it, on which meaſure 22 Feet 2 Inches; move theſe two Cords till they joyn together in the Point D; ſo ſhall the Angle D B E be 43° : 22′.

PROB. 25.

To meaſure by the Table, an Angle, either on Paper, or on the Ground.

TO meaſure the Angle A B E, firſt place 30 Feet on each Side from B to C and D; then meaſure the Diſtance C D, and you will find it to be 22 Feet 10 Inches; then look in the Table under the Title Baſe for 22 Feet 10 Inches,

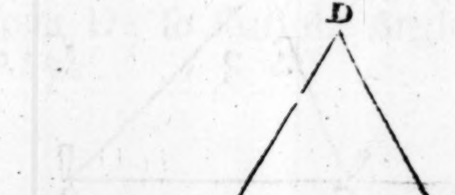


ches, and againſt it on the Right Hand, yon will find 44 Degrees 44 Minutes, which is the Meaſure of the Angle A B E.

Here Note, *That altho' by the aforegoing Table, you may lay down any Angle by the aforegoing Method; yet the Operation will be much more exact, if for all Angles exceeding 90 Degrees, yon make uſe of their Complements to a Demicircle, as is uſually practis'd on the like Occaſion.*

For Example.

If it be required to make on the Point B, on the Line A B, an Angle of 120



Degrees; lengthen the Line A B to C, and place 30 Feet from B to C, and make the Angle D B C, equal to the Complement of 120 Degrees, to a Demicircle, or 180 Degrees, which is 60 Degrees, as before directed, ſo will the Angle A B D, be 120 Degrees.

CHAP. I.

Of Fortification in General.

FORTIFICATION, which is alſo called *Military Architecture*, is an Art, which by the means of *Arithmetick* and *Geometry*, teaches the Way to Fortifie a Town or City, ſo as to hinder the Invaſion of an Enemy, and, if poſſible, to render their Efforts of no effect; and this to be done with ſo ſmall a Number of Men, in compariſon of thoſe of the Enemy, as to hinder the Progreſs of an Ambitious Prince; to which purpoſe, it has been the utmoſt Endeavours of the ableſt Engineers, for many Ages, to ſupply the Defects of this Art, and as far as in them lies, to render a Place Impregnable.

The *Dutch* Manner of Fortifying of Places, gained a great Reputation, and was generally received all over *Europe*; but in the War 1672, 1673, *&c.* it was evident, That the greateſt part of their beſt Fortified Places were taken in three Weeks time, which has (ſince that time) much leſſened their Reputation; principally for not having Cazemats, or (if they have any) they are very ſmall; and the Flanks, which are the principal Parts of Defence, being Perpendicular to the Courtain, cannot diſcover all the Ditch, and conſequently the Enemy can lodge themſelves therein, without any fear of being ſhot from the Flanks; to remedy which Inconvenience, Count *Pagan* (an Engineer of great Experience) Printed a New Method of Fortification, wherein he makes his Flanks at Right Angles with the Line of Defence, and no Second Flank, as the *Dutch*.

But ſince my Deſign is to be as ſhort and plain as is poſſible, I ſhall proceed to give you firſt the Explanation of the Principal Terms of this Art.

CHAP. II.

The Explanation of Terms Ichnographick, of a Place Fortified.

THE following Figure repreſents a Demi-Hexagon fortified; which, as well as all other equal ſided Figures, is called a Polygon; A B C D is called the Interior Polygon, and GKVX the Exterior; each Side of the Interior Polygon, as A B, is called the Interior Side, and each Side of the Exterior Polygon, as G K, is called the Interior Side. When the Polygon Interior and Exterior are regular, as here, they have the ſame Center, as S, which is the ſame with the circumſcrib'd Circle: The Diameter of the Circle deſcribed about the Interior Polygon, is called the little Radius, as S A; and the Diameter of the Circle deſcribed about the Exterior Polygon, is called the great Radius, as S G. Where one fortifies by the Interior Polygon, it is called fortifying from without; but when one fortifies by the Exterior Polygon, it is called fortifying from within. A G F E repreſents the Plain of a Demi-Baſtion, which is compoſed of the Demy-Gorge A E, the Capital A G, the Flank E F, the Face F G; if the Flank E F, or H I, be perpendicular to the Courtain, it is called a Right Flank; but when it makes an Obtuſe Angle with the Courtain, it is call'd an Oblique Flank, H I K L M P O N, is an entire Baſtion, which is alſo called a Bulwark, which is compoſed of the like Parts with the former, and a whole Gorge, which is repreſented by the Line H N, drawn from the extremities of the Flanks H I and N L; the Flank L N is cut by the Epaul or Orillon L M, which being round is called a Round Orillon, otherwiſe it is called a Square Orillon, as Q R; it covers a part of the Flank, which for that end is retired inward, and for that reaſon is called the retired Flank and cover'd Flank, and alſo Cazemat, or low Place, as O P, and the Line N O and M P, is called the Retrenchment of the Flank, or the Enforcement of the Cazemat; the Line E F has been call'd the Flank, becauſe it ſerves to defend the Face I K, for to flank, in Terms of Fortification, ſignifies to defend. It is called Flank *Frichant*, becauſe the Muſketeer which ſhall be in its Extremity E, can ſhoot and fricher againſt the Face I K, which makes the Line E K, drawn from the extremity of the Flank E, to the Point K of the oppoſite Baſtion, be called the Line of Defence *Frichante*, or ſimple Line *Frichant*; it's alſo called the great Line of Defence, and the Line Raceing, or Line of Defence Raceing; the Line K T, is called the little Line of Defence, or ſimply the Line of Defence, which is formed by prolonging the Face K I, to T, where the Muſketeer being, cannot ſhoot againſt the Face I K, but only race it; and then the Part of the Courtain E T, is called the ſecond Flank, and alſo fire in the Courtain, becauſe from all the Parts of the ſecond Flank H T, one can ſhoot and make fire againſt the Face G F. There is not always a ſecond Flank, as in the Courtain Y Z, and then there is not any Line *Frichant*, but only a Line Raceing, as Y V and Z X, and in this caſe the Flank is called the Flank Raceing, becauſe from its extremity Y and Z, one can only race the Face of the oppoſite Baſtion, by which you ſee that the Flanks are as the Arms of a Place fortified; alſo it is this part which the Enemy endeavours moſt to ruine, more eaſily to paſs the Ditch.

The Angle A S B, is called the Angle of the Center; and the Angle A B C, the Angle of the Polygon, which one may call the Angle of the Interior Polygon to diſtinguiſh it from the Angle GKV, which may be called, the Angle of the Exterior Polygon; the Angle F E H, which is made by the joyning of the Flank E F, and the Courtain E H, is called the Angle of the Flank.

The Angle E F G, which is made by the joyning of the Flank E F, with the Face F G, is called the Angle of the *Epaule*, or ſimply the Epaul, from whence comes the Word *Epauler*, which ſignifies to cover the Flanks or Shoulders of him which ſuſtains it, in ſuch ſort that they be not diſcovered on the Side; thus one ſees, that thoſe that defend in the Flank E F, are covered and Epauler by the Face F G, the which in this caſe is called Epaulment.

The Point of the Angle of the Interior Polygon B, is called the Center of the Baſtion.

The Angle A F E, which is made by joyning the Center of the Baſtion, and the Angle of the Epaul, by the Line AF, is called the Angle forming the Flank.

But Monſieur *Ozanam*, and ſome others, who make the Flanks to be drawn from the Center of the Polygon, make the Angle *b* S X, to be the Angle forming the Flank.

The Angle I K L, which is made by the joyning of the two Faces K I and K L at the Point of the Baſtion, is called, the Angle of the Baſtion; alſo the flanked Angle, becauſe it is flanked and defended by the two oppoſite Flanks.

The Strait Line drawn from one flanked Angle to the other, and which marks their Diſtance, as G K, is called the Baſe Line, which before we called the Exterior Side of the Polygon.

The Line E B, which is compoſed of the Courtain E H, and the Demi-Gorge H B, is called the Courtain prolonged.

The Angle X *a* V, or re-entring Angle, which is made by the meeting, or rather Interſection of the two Lines Raceing, and which is Obtuſe, is called the Angle of the *Tenaille*, or ſimply Tenail; from whence the two Lines *a* V, and *a* X, are called alſo Tenails, it is called the Exterior flanking Angle, for to diſtinguiſh it from the Interior flanking Angle, which is made by the meeting of the Line Raceing, and the Flank, when the Flank is Raceing; that is to ſay, when there is no ſecond Flank, as V Y *b*, otherwiſe when there is a ſecond Flank, by the meeting of the Line Raceing, and the ſecond Flank, as K E F.

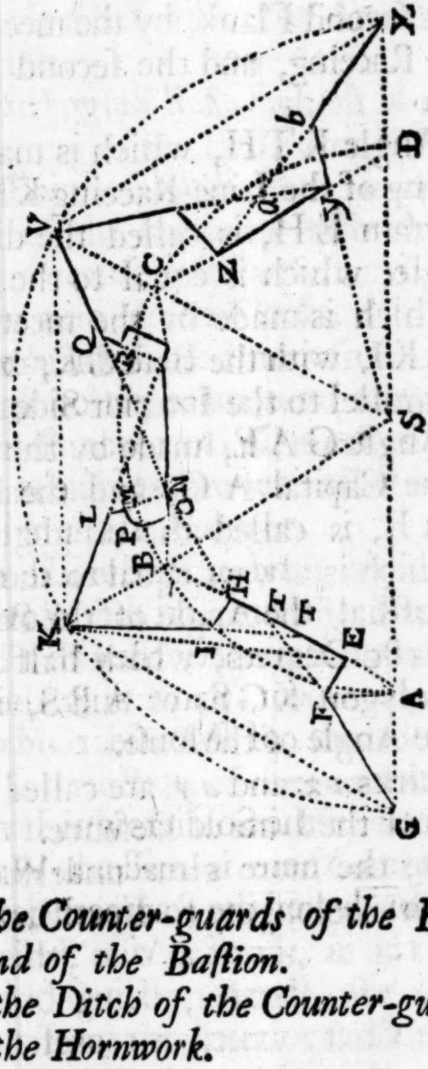
The Angle K T H, which is made by the meeting of the Line Raceing K F, and the Courtain E H, is called the diminiſhed Angle, which is equal to the Angle GKI, which is made by the meeting of the Face KI, with the Baſe G K, becauſe G K is parallel to the Interior Side A B.

The Angle G A E, made by the meeting of the Capital A G, and the Demi-Gorge A E, is called the Angle of the Gorge, which is always equal to the Complement of half the Angle of the Polygon K G S to 180 Degrees, which half Angle of the Polygon K G S, or A B S, is alſo called the Angle of the Baſe.

The Lines *a z* and *a y*, are called Complements of the Line of Defence.

But for the more clear underſtanding of the Parts belonging to Fortification in *Figure* 2.

B, *are the Bulwarks or Baſtions.*
D, *the Ditch of the Place.*
E, *the Ravelins.*



F, *the Counter-guards of the Ravelin, and of the Baſtion.*
G, *the Ditch of the Counter-guards.*
H, *the Hornwork.*
I, *the Ditch of the Hornwork.*
K, *the Crownwork.*

L, *the Ditch of the Crownwork.*
M, *the Half-Moon.*
N, *the Ditch of the Half-Moon.*
P, *the Place of Arms.*
Q, *the Glacis.*
O, *the Covert-way.*
a b c, *the ſingle Tenail before the Courtain.*
d e f g h k, *the double Tenail before the Courtain.*

There are again other Works which I have not here repreſented, as the great and little Lunets, which are put on the Side of the Ravelins for to cover them, the Half-Moons on the Points of the Baſtions, the Hornwork crowned, the ſingle and double Tenails, and other the like Inventions. But as theſe ſort of Works are not found but on Paper, they that have a deſire to ſee them, may find them in the Tranſlation of Monſieur *Vauban*'s Fortification.

For to cover the Soldiers which fire on the Beſiegers, there is made a Wall on Terraſs, or top of the Rampart next the Ditch, of the height of a Man; this Wall is called, the Parapet, being built all round the Place, which is repreſented by the Letter R in *Fig*. 2. And becauſe the

Violence of the Cannon ſoon ruines this Parapet, if it be not of a ſufficient Thickneſs; it is cuſtomary to give it three Fathoms thickneſs, which renders it of a reaſonable Solidity; but becauſe, according to the Method that is now made uſe of to batter Towns, the Parapet is ſoon ruined: For to make the greater Reſiſtance and Obſtacle to the Enemy, the Earth, on which leaves the Parapet, has 10 or 12 Fathoms thickneſs towards the Foot, which leaves on the Top of the Terraſs, behind the Parapet, 5 or 6 Fathoms broad for the Soldiers to paſs, and for the uſe of the Cannon; and it is that which is called, the *Terre Plain*, or Walk of the Rampart marked with the Letter T: On the Flanks are made Holes in the Parapet, for the Mouth or Muzzle of the Cannons to paſs through; and theſe Holes or Windows marked with the Letter A, are called Embraſures; and becauſe between one Embraſure and the other, there remains a part of the Parapet, the ſame as between two Windows in a Chamber, where is left a Wall to ſeparate them, the Pieces of the Parapet are called Merlons.

For to batter far into the Campaign, is oft raiſed a Maſs of Earth, repreſented by the Letter C, which are called Cavaliers, and there is placed the Cannon to ſhoot far on the Enemy. To the end to cover the Soldiers which are poſted beyond the Ditch, there is raiſed a Parapet of the height of a Man, the Earth of which is ſloped like the Side of the Roof of a Houſe, till it loſes its ſelf in the Campaign, which is called the Glacis, marked by the Letter G. The Space between that Rampart and the Ditch, marked C *b*, is called the Covert-way, which goes quite round the Place. The Space marked P, is called the Place of Arms, in which place the Soldiers retire when they are preſſed by the Enemy, to the end that there they may be more ſecure, and the better defend themſelves; theſe Places of Arms are covered by Parapets marked with the Letter *q*, which are called Traverſes.

The *Eſcarpe*, is that part of the Wall of the Town, which is a little intalude, or ſloping, and leans towards the Town, when that on that Wall there is one raiſed upright, that part of the Wall ſo built, is called *Chemiſe*, on the Top of which, is placed a *Faſcica*, or Edge of Stone, above which is placed the Parapet.

The *Counterſcarp*, is the Wall of the Ditch, which ſupports the Covert-way; ſo that to be lodged on the Counterſcarp, properly ſpeaking, is to be lodged on the Brink of the Ditch, but at preſent they generally abuſe this Term; for when the Enemy is at the beginning of the Glacis, they ſay they are on the Counterſcarp.

Note, *That for the better covering of the Soldiers, the Parapet is made higher than a Man, that he cannot fire at the Enemy, till he has mounted himſelf on the Foot-bank, or Banquet, which, for that purpoſe, is made all round the place: But ſince all the Parts of a Fortification ought to be rendred as uſeful as may be, and to have their reaſonable force, here follows ſuch* Maxims *as muſt be obſerved.*

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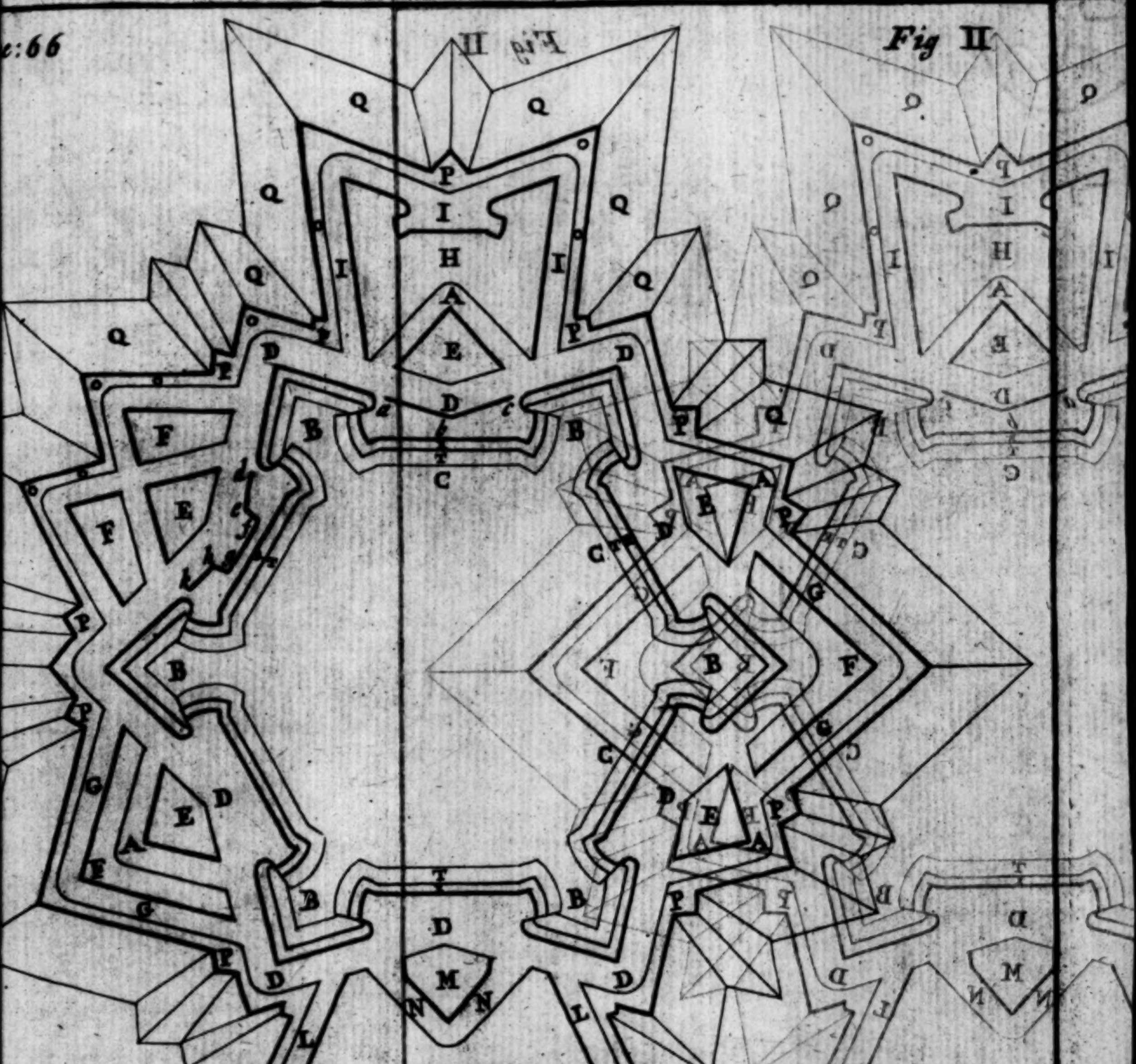
Fig II



CHAP. III.

General Maxims to be obſerved in Fortification.

MAXIM I.

By the advanced Works, to keep the Enemy as much as is poſſible from the place, I mean, by thoſe Marks, the Elevations of Earth cloathed or caſed with their Ditch.

THIS Maxim is undeniable, for as much as it muſt require much more time, and cauſe much more danger whilſt the Enemy are obliged to begin their Attacks very far, and for to make many Works, than when they have but to paſs the Ditch, and make a Breach in the Wall of a Town.

MAXIM 2.

To hide the Entrance into theſe Works, as much as is poſſible, from the Batteries of the Enemy.

This Maxim is no leſs natural, being evident, that the Violence of Cannons ſoon makes a Breach in thoſe Places too much diſcovered; for which reaſon the Works ſunk into the Earth, ought to be moſt eſteemed, it being almoſt impoſſible to batter them, without being firſt arrived on the Brink of the Ditch.

MAXIM 3.

Make all the Parts of a Fortification ſo, that the Baſtions, and all other Works, not only defend its ſelf, but be defended by another, they intirely ſecuring one the other.

This Maxim is evident from its ſelf, for as much as a Work, becauſe of the height and thickneſs of its Walls, doth not defend its ſelf very well, when that the Enemy is near it, therefore there is need of another Work to defend it; for which reaſon one ought to defend the other, and the advanced Works ought to be defended by thoſe on the Side of them.

MAXIM 4.

To fortifie the Walls and the Ramparts, ſo that they can reſiſt the greateſt Effort of Cannon.

This Maxim is not leſs neceſſary to be obſerved than the former; it being evident, that for to ſupport it, one muſt oppoſe Cannon to Cannon, at leaſt of an equal force; and experience teaches, That if a Cannon-Bullet ſhot more than 1000 Paces, enter 13 or 14 Feet in the Earth, a Battery of many Pieces of Cannon ſhot all at a time, will eaſily fling down a Rampart, if it be not of a great thickneſs.

MAXIM 5.

Never make any Work, that every Side of it ſhall not be ſeen by thoſe of the Place, that there be not found the leaſt Place where the Enemy can hide themſelves.

If this Maxim is not obſerved in a Fortreſs, and that a Work intire, or alſo part of that Work, be not ſeen by thoſe within, no Perſon can defend it but with Sword in hand; for that which ſhall be in the leaſt degree more expoſed, than it has for its defence from the Fortreſs, is not defended but with great difficulty: It is therefore neceſſary, that all be viewed far off, and that one Work diſcovers perfectly the other for to ſhoot on thoſe which Attack it,

MAXIM 6.

Never make any Work ſo far from the others, that it cannot be defended by the Musket, which ordinary will kill but 120 *Fathoms.*

This Maxim has ſeem'd to have been diſputed by ſome Engineers, tho' it ſeems to me to have no difficulty in it; ſince to put the Works the one from the other Cannon-ſhot, it's confeſſed, makes them Machines of great Violence, but are eaſily ruined by the Batteries of the Enemy, which in the execution want much of the quickneſs of the Musket.

Maxim 7.

To have ſome places in the place more high than the reſt of the Works, to batter the Enemy at a great Diſtance.

This Maxim is very neceſſary, ſince without ſome elevation, the Enemy is eaſily hid, and may approach without being viewed.

CHAP. IV.

Reflections on the aforegoing Maxims.

Reflection I.

THE Firſt Maxim, which is for to keep the Enemy, as far from the Body of the Place, as is poſſible, by the Outworks; ought not to be underſtood in ſuch ſort, that the Outworks be ſo far diſtant, and in ſo great a Number, that they require a great Garriſon for to defend them; for it's certain, that in multiplying the Outworks, one not only increaſes the Expence, but alſo the pain and trouble for to defend them well; therefore there muſt be Diſcretion uſed, not only to make no more Outworks than are abſolutely neceſſary, but alſo to diſpoſe them ſo in the ſeparating them one from the other, that they cannot be Attack'd altogether, and that they can be eaſily ſuccoured.

REFLECTION 2.

The Second Maxim requires alſo ſome regard, which is to hide the Works, as much as is poſſible, from the Batteries of the Enemy, for they ought not ſo to be hid that they cannot be diſcovered: I intend by the hiding of them, their inſide only, that at a great diſtance from the Place, it with all its Outworks may appear as a raiſed Field, in ſuch ſort that they cannot Batter it, till approached near, which will coſt the Beſiegers much before they arrive there. I could wiſh notwithſtanding, according to the Firſt Maxim, there be many Places raiſed for to Batter the Enemy in † Barbe; and for to diſcover their Trenches, without which, they can approach, without being diſcovered, but theſe ſort of Elevations of Earth, which are called Commanders, or Cavaliers, ought not to be made, but in the Body of the Place, to the end, that they may not be ſeized by the Enemy, and made uſe of by them, to the Diſadvantage of thoſe within.

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† Note, *Thoſe Guns raiſed high to ſhoot over the Top of the Parapet, becauſe their Fire ſinges or burns the Graſs, or Herbs on the Glacis, or Slope of the Top of the Parapet, are ſaid to ſhoot in Barbe.*

Reflection 3.

The Third Maxim has ſome particular Difficulties attends it, for whilſt one ſays, That the Works moſt advanced into the Country, ought to be defended by thoſe of the Place next to them, this ought not always to be underſtood in ſuch ſort, that the Head of each of theſe Works can be defended by him that is behind it; for it is often impoſſible, when there is many of them one before another, for then muſt thoſe neareſt to the Town, be made of an exceſſive height; therefore ſuch an Advantage cannot be found, but when the Fort is ſituate on a Hill, or on the ſide of a Hill; then it may be, that a Work plac'd on the ſloping of the Hill, diſcovers, in ſome manner, the Head of that which is before it, if it be not in ſome place more high than the reſt; but if it be in a level Ground, as are moſt Forts, it is plain, that which is behind cannot ſhoot on the Counterſcarp of that which is before it, if it is not in ſome Places more high than the reſt; therefore each Work muſt defend its ſelf its

Head. I underſtand by the Head of a Work, that part which is directly oppoſite to the Enemy.

REFLECTION 4.

The Fourth Maxim is ſuch, that it is certain that the old Walls that we find in thoſe Towns, agree not with, ſince therein are rarely found more than 4 or 6 Feet thickneſs, and often without any Terraſs or Walk of the Rampart. Whereas the Wall of a Strong Place, muſt have at leaſt 10 or 12 Feet of thickneſs ſupported by Terraſs, or a great Plat of Earth of 10 or 12 Fathoms thick; and becauſe a Soldier, covered by ſo great a Terraine, will be too far from the Ditch for a good Defence, one ought to put on the Top of the Rampart towards the Ditch, a Wall of 18 or 20 Feet thick, and of 5 or 6 Feet high, for to cover them that defend; and this is the Wall which is called the Parapet of the Terraſs.

REFLECTION 5.

The Fifth Maxim is of too great a conſequence to be in any manner neglected; To know that there is not any part about a Fortification, which is not ſeen from the backſide of a Place proper for well defending it, one Example will make this Important Maxim well underſtood. See *Fig*. 3.

In which Fortreſs the Enemy being lodged in the Point N, he will be covered by the height and thickneſs of the Wall, which cauſes that the Soldiers cannot ſhoot to the Foot; the ſame happens if the Enemy ſhall take the Works Y and O, being poſted in the Point P, then the height and thickneſs of the Wall, which keeps back the Soldiers, covers them ſo that it will be impoſſible to ſhoot them.

If the Enemy have paſſed the Ditch, and was poſted at the Foot of the Tower in X, neither the Soldiers poſted in R, nor Z, can ſhoot them, becauſe the two Shots of Musket R *b* and Z *b*, cannot touch the Tower but in *a* and *c*; thus all the Triangle *a b c*, is a Space wherein the Enemy is covered and cannot be ſeen from any part of the Place; but if the Enemy Attack the length H N, all the length D B, defends it; the ſame if they Attack G G, which are defended by the two Faces A C and D B.

If the Enemy Attacks the Face A C, they ſhall be battered from all the length

D F,

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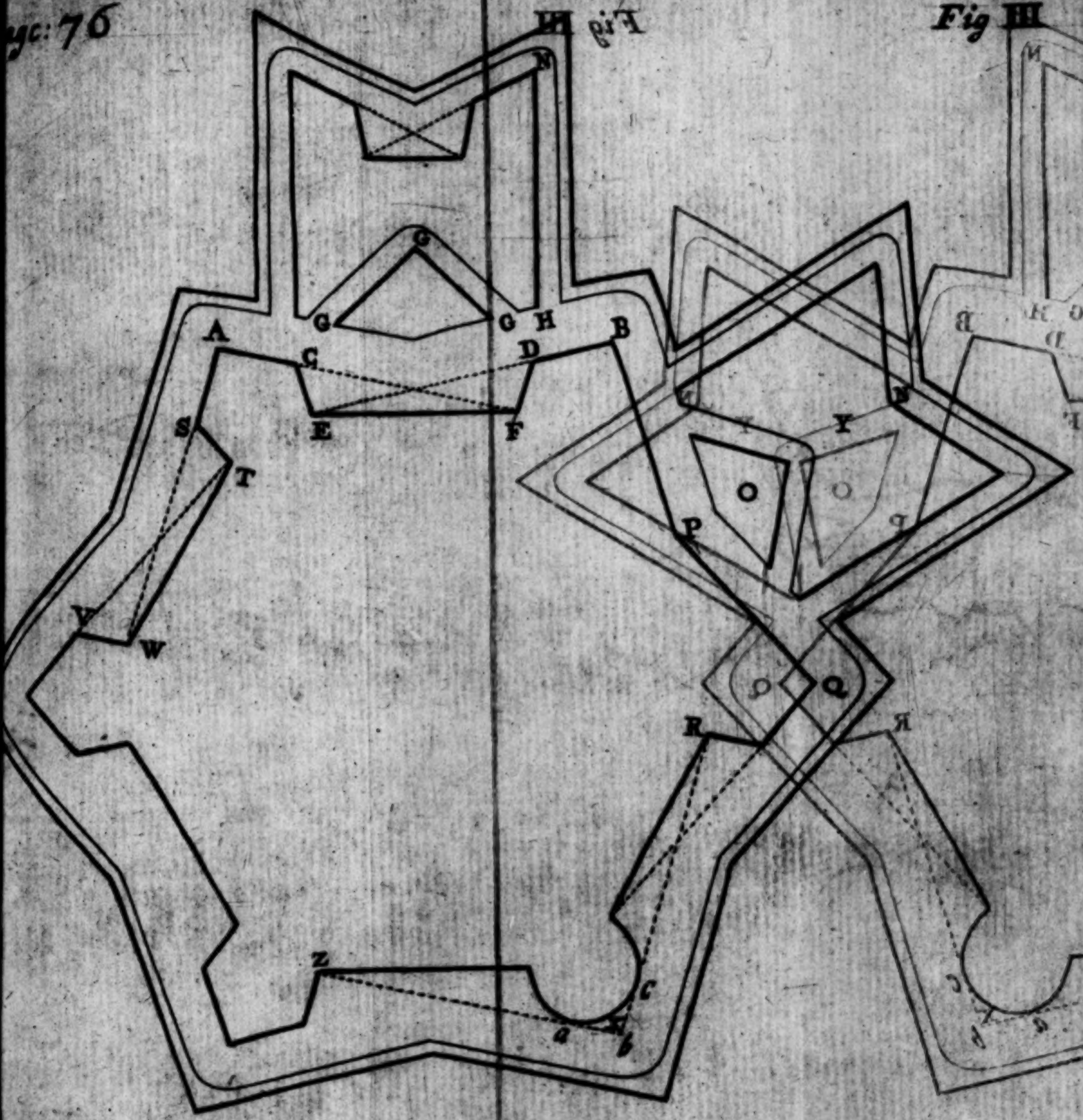
Fig III



D F, where the Cannons and Musketeers are placed; the ſame will arrive, if they Attack the Face S A, they will be battered from all the length V W; and if they Attack the Point A, they will be battered from the two Flanks D F, and V W; and becauſe they receive Shots from the one part, and the other in that place, which is the moſt advanced part of the Baſtion; therefore is the ſaid Point A, called the flanked Angle; there is not then any part of this place that is not ſeen from ſome part or other, except the two re-entring Angles N and P, and the part of the Tower *a b c*, and by conſequence, all the reſt are defended from far, except the aforeſaid Figures, which are never worth any thing.

Reflection 6.

For the laſt Maxim, we have ſpoken ſufficiently already of that.

CHAP. V.

Particular Maxims of Fortification.

Maxim I.

THE largeſt Baſtions are the beſt, becauſe they are the moſt capable for to contain Earth therein, to make Retrenchments, they are alſo capable to contain more Men and Cannons proper for their Defence; this Principle ought not nevertheleſs to be underſtood in ſuch ſort, that the Baſtions be as large as little Cittadels, which will, in the firſt place, cauſe a vaſt Expence; and ſecondly, they will require too many Men for to guard and defend them.

Monſieur *Errard* will have a Baſtion capable of 200 Men, for as much as it is good to reſiſt an Aſſault where near 40 Men on the Front mount at one time on the Breach.

MAXIM 2.

The greateſt Flanks are the beſt, becauſe the Baſtion doth no longer defend its ſelf, when the Enemy is in the Ditch over againſt the Flank, which is the Place where it is uſual to Attack it, and then all the Defence is from the Flank of the oppoſite Baſtion; the largeneſs of the Flank is therefore neceſſary as well to place the Cannon, as to lodge the Muſketeers thereon.

MAXIM 3.

The greateſt Gorges are the beſt, becauſe they are the Entrance of the Baſtion, which ought never to be cooped in, it being the part where one Intrenches himſelf before he ſuffers an Aſſault. Theſe Intrenchments conſiſt of a Ditch with a good Parapet, and a Palliſade marked in *Fig.* 4. with the Letter *p*, of which are made therein ſometimes 2 or 3, one behind the other, as in the Figure.

MAXIM 4.

The Point of the Baſtion ought not to be too ſharp, becauſe it is eaſily ruined by the Cannon; and being too Obtuſe, or Blunt, it diminiſhes the Flanks, and renders the Baſtions leſs; this Angle ought never to be leſs than 70 Degrees.

MAXIM 5.

The Flanks ought never to be Perpendicular to the Courtain, but ought to make an Angle with the Courtain a little more open than a Right Angle, or 90 Degrees, becauſe being a little more open, it better diſcovers the Counterſcarp, otherwiſe the Embraſures ought to be more Oblique, and conſeqnently leſs ſolid.

MAXIM 6.

They pretend that the Baſtion filled all with Earth, is better then that in which the Gorge is void, the Earth being neceſſary for the Intrenchments.

CHAP. VI.

Concerning ſeveral Queſtions relating to ſeveral Parts of a Fortreſs.

QUEST. I.

THE Firſt Queſtion is concerning the Ditch of the Place, which ſome will have very deep, but not very broad; and others will have it very broad, and not have any reſpect to the depth; ſome will have it dry, and others full of Water; in which caſe it is difficult enough to reconcile them, there being many Advantages on the one ſide and on the other: I ſay, that notwithſtanding the Apprehenſion which one has, that the Enemy doth not eaſily fill up the Ditch of a Town, by making it large and not very deep, or by making it very deep, and not very large, it comes to the ſame thing, in caſe that one digs in breadth that which one retrenches from the depth, or that one digs in depth that which one ſpares in breadth, ſince for to fill them there muſt be as many Faſcines for the one, as for the other; the deep one has this Advantage, that one doth not diſcover the Foot of the Rampart for to make therein a Breach with the Cannon for the Miners to lodge in before they have made a Well or Vent on the Covert-way as deep as the Ditch, and there deſcend their Cannons, and therewith make a Breach in the Wall of the Ditch; and this is called to come to the Sap of the Counterſcarp. But if the Foot is diſcovered more in the very broad Ditch, it has this Advantage, That from the Top of the Rampart, the Counterſcarp, at a diſtance, is better diſcover'd, where the Cannon and Musketeers fire more eaſily, as if it was on even Ground; altho' there be this Diſpute, there is a general received Rule at preſent amongſt Engineers, which is to make the breadth of the Ditch, near the length of the Flank of the Baſtion, in Places regular, which being ſo made, all the Faces diſcovering the Ditch, gives more liberty to the Cannon, and to the Musketeers for to make a Vigorous Defence.

QUEST.

Queſt, 2.

Is whether the Ditch full of Water is better than a dry Ditch? I Anſwer in the firſt place, That very often it is not in the choice of the Engineer; that in *France* the greateſt part are dry for want of Water, and in *Flanders* the greateſt part are full of Water, becauſe the Country is full of Water; therefore the Engineer muſt regulate himſelf according to the Situation of the Place.

In the ſecond place I Anſwer, That there are Advantages on the one part, and on the other, That if the Ditch is dry, the Beſieged can there defend it Foot by Foot, for to hinder therein the Paſſage of the Enemy, and often that ſucceeds better, than if it was full of Water, but that depends very much on the Courage of the Beſieged. As for thoſe that are full of Water, one may ſay for their Advantage, That the Enemy, for to give an Aſſault, muſt neceſſarily fill them with Faſcines; but if the Water is not deep, the Enemy may paſs it with very little difficulty; the beſt are thoſe where the Water is very deep and rapid, for then the Paſſage will be almoſt impoſſible: But theſe rapid Currents are not found any where, but in great Rivers, which do not eaſily incompaſs a Town on all Sides, the Arms of which become ſtill and quiet, if it turns about many Half-Moons.

The greateſt Advantages of a Fortreſs, are when one can fill its Ditch with Water, and empty it at diſcretion; but to that end there muſt be a Floodgate to the Ditch, and a Fountain, or River near it, which is difficult to find.

They firſt alledge againſt a Ditch full of Water, that the Sallies are dangerous, becauſe that if they are repulſed, and put into diſorder, they are in ſuch a Confuſion, that they Drown themſelves: But, I Anſwer,

Firſt, That the Sallies ought to be ſeldom, and with ſo much precaution, that they always have the Advantage, which depends much on the Conduct and Judgment of the Governor.

Secondly, For to remedy the Inconveniences, in caſe of diſorder, the Place of Arms, and the Covert-way muſt be made large.

QUEST. 3.

Is touching the Cloathing, or Coating of the Walls, to know if it be better to coat them with Stone when one can, or with Brick, when the Earth of the Place is proper for it, or if one ought to content himſelf for to Coat it with Sod or Turf, cut in form of a Coyn of Wood, which one puts for to hoiſt the Breech of a Cannon? I reply,

Firſt, That it is not always in the choice of the Engineer, nor yet of the Prince, to Coat the Walls in ſuch manner as they will; for as much as in *Holland* they have no Stone, and in *France* often they have neither Brick nor Sod, in which caſes neceſſity obliges to coat the Walls with the Matter which is found on the Place; thus making diſtinction betwixt that which can, and that which cannot be done, and comparing one ſort of Coating with another, that of Stone being the moſt ſtrong and moſt compact, will endure a long time, whole Ages, and thereby makes amends for the Expence, which has thereon been beſtowed, but in a Siege the Splinters, which the Cannon there makes, are very pernicious to the Beſieged.

The Coating of Earth has the Inconveniences, that it muſt be repair'd every Year, and that the Flanks ought to be ſtrait and conſequently defective, being almoſt impoſſible to cover them with a ſolid Orillon; the only Advantage is, that the Bullets of the Cannon do therein only make a Hole of its bigneſs, which renders it more difficult to make a Breach.

As for that of Brick, it muſt be confeſſed, it is of all other, (provided the Brick is ſoft, and not too much Burnt, the beſt; for ſuch a Wall will continue, and has the Advantage in all reſpects of Sodding.

QUEST. 4.

Is concerning the Cavaliers, which ſeveral are of Opinion, ought to fill the Baſtions, (as in *Fig.* 4.) is marked with the Letter D, others place them in the Center of the Gorge, as marked with E; others in the middle of the Courtain, as at C, and ſome others in the ends of the Courtain, as at S. As theſe are Elevations of Earth, and moſt an end coated, it is certain, that occupying the Baſtion as at D, its height will cover the Enemy in the

Breach, on the which they can no more ſhoot.

But if they are placed in the middle, or on the ends of the Courtain, as has formerly been done by the Chevalier *Ville*, it is evident, that being ſo ſituate, they cannot defend the next Baſtions, while it is Attack'd by the Enemy, being there of no uſe, but to defend the Country. But being placed in the Center of the Baſtion at E, they ſeem to me to be better ſituate, not being ſo near the Faces, and conſequently can better defend the Breach; beſides from this place, one can ſhoot on the Face of the next Baſtion, and hinder the Enemies lodging there. Count *Pagan*, and after him Monſieur *Vauban*, makes theſe Cavaliers with a Point like a little Baſtion in the Center of the Gorge, which the latter calls Tower-Baſtion, and has the ſame Parapet and Terraſs as the Baſtion its ſelf; they both incompaſs them with a Ditch, to ſerve as a Retrenchment. Sometimes in the room of a Cavalier, ſome content themſelves for to raiſe the Point of the Baſtion in Terraſs, which is a conſiderable Advantage for to cover the Soldiers which are to defend the Baſtion, and this is called *Barbette*; but the Breach being made, is of no uſe, and the *Bar-*

bette of the next Baſtion is eaſily ruined, being very much expoſed to the Batteries of the Enemy, repreſented by the Letter I. Some late Engineers, inſtead of raiſing the Point of the Baſtions, abaſe it, and cut the Terraſſes circular, as is repreſented by K; but, in my Judgment, with little reaſon; for as much as the Breach being made below where the Terraſs finiſhes, the Enemy will find in this *Barbette*, a Lodgment ready made, where one cannot from the height of the Parapet ſhoot on them.

QUEST. 5.

Is concerning the Point of the Baſtion, which is called the flanked Angle, about which there has been very great Diſputes for theſe 30 or 40 Years. The *Dutch* have maintained, that this Angle ought to be an Acute Angle: Others, as the *Spaniard*, have maintained, that this Angle ought to be Obtuſe: Others, as the *French*, have maintained, That this Angle ought to be a Right Angle. The *French*, without doubt, are in the right, it being certain, that a Right Angle reſiſts better than the Acute or Obtuſe; it is true, that this Angle being made Acute, makes the greater

Flanks,

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Fig IIII

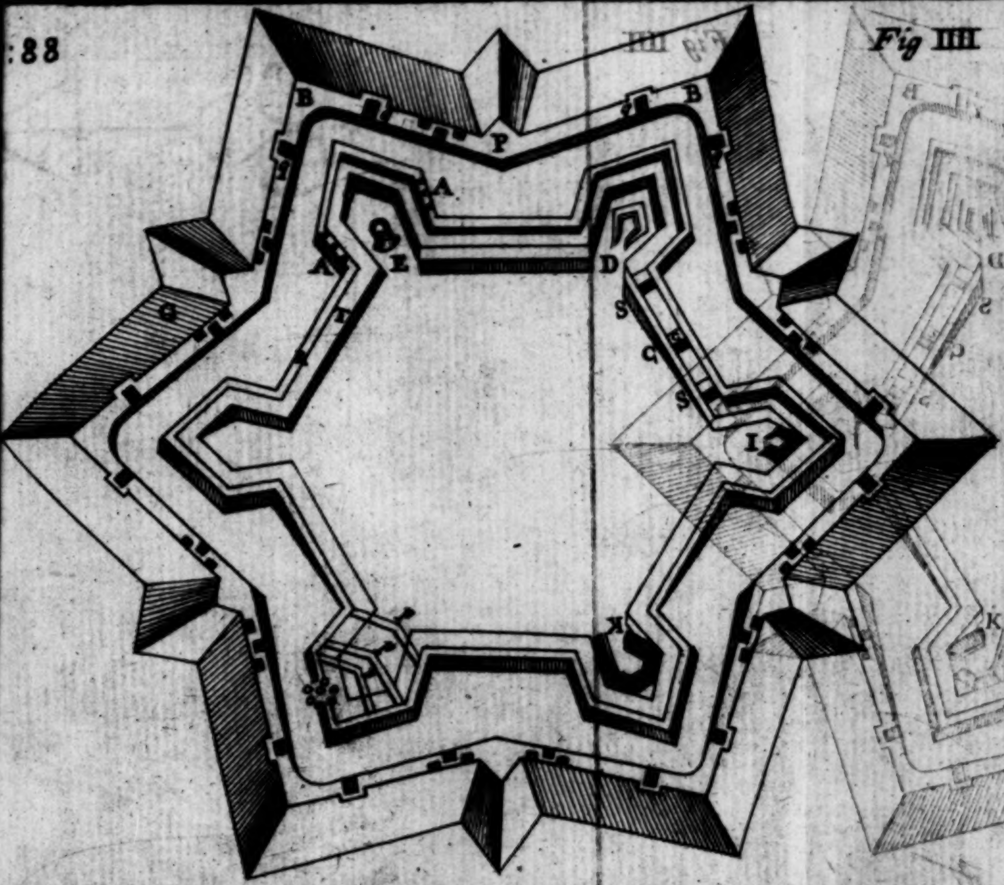

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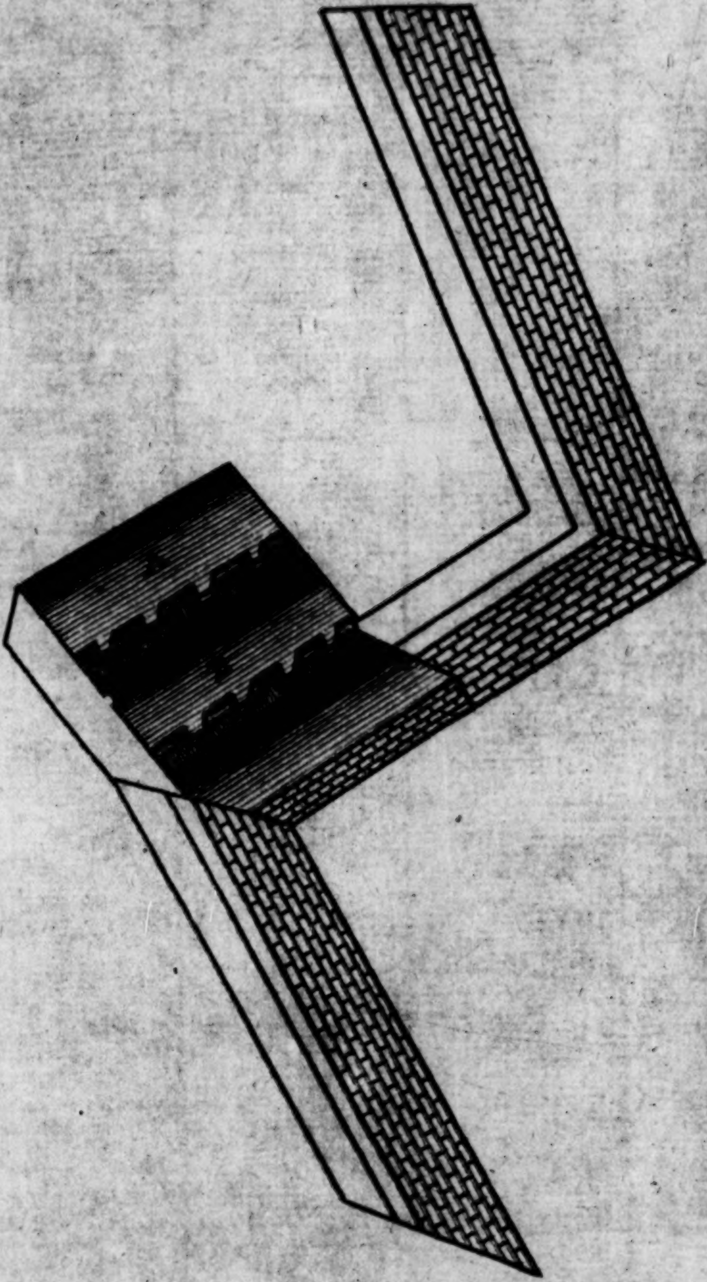
Fig: V



Flanks, and gives part of the Courtain for the Defence of the Face.

Quest. 6.

Is concerning the Cazemats; it having been near 30 Years a thing generally received amongſt the Engineers, for to make Cazemats in the Flanks of the Baſtions, which were made as Vaults under ground, with Holes in the Walls for to paſs the Muzzle of the Cannon ; though ſince that time, the Bombs falling ſometimes on them, has leſſened their Reputation, or Value ; but the Inconvenience ariſing thence, may be remedied, by putting a good quantity of Earth upon them, but the greateſt Inconveniency which in the end has made them be laid aſide, has been the Smoak which cannot therein diſperſe it ſelf ; ſo that at preſent they make thoſe Places uncovered on the Top, and only cover them with a good Parapet of Cannon proof: The Battery which is above on the Rampart, is called, the high Battery, or Place marked in *Fig.* 5. with the Letter A, and the Place where the low Battery is placed by the Letter B, which low Battery is always employed to hinder the Enemy from paſſing the Ditch.

Quest.

QUEST. 7.

Is concerning the Epaul and the Orillon; about which, there has been ſome ſmall Diſpute. The Epaul is a part of the Flank which covers the Batteries, which is ſquare, as Count *Pagan* has made them. The Orillon is the ſame part of the Flank, of a round Figure, as Monſieur *Vauban* has made them †; the Queſtion is not very conſiderable, for if one would there place the Musketeers, it is plain, that the Epaul is moſt convenient, having all its Shots directed toward the oppoſite Baſtion; but if one ſearches nothing but the Solidity, the Orillons are more ſtrong, and gives more liberty to the Batteries in the corner. As for their Meaſure, Monſieur *Vauban* makes his Orillon one third part of the Flank; but Monſieur *Coeborne*, who there places his Musketeers, makes his much larger, as one may ſee in the Draught of *Bergenopzoom*. As for the Epaul, or Square Orillon of Count *Pagan*, it is made of the half of the Flank, having, by that means, the greater force and capacity.

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† Note, *Both ſorts are call'd* Orillons.

QUEST. 8.

If the Line of Defence ought to be more than 120 Fathoms? To which it may be anſwered, That it ought not to exceed that length; for altho' a Musket well fortified, and much charged, has kill'd Soldiers 150 Fathoms, as *Fournier* teſtifies, yet one ought not from thence to draw a Conſequence for the ordinary Muskets; and if Monſieur *Vauban* has often given to the Line of Defence 135 Fathoms, he reforms that Diſtance in placing his Musketeers in the Ditch.

CHAP.

CHAP. VII.

The Advantages which may be drawn from the Figure in each Polygon.

WE having already ſhewn in *Chap.* 4. that the Circular Figure, nor the ſimple Tenail, that is, when two Walls joyn together in a re-entring Angle, cannot in a Fortification produce a good effect, becauſe the Circular has a part that is not ſeen from the place, and a ſimple re-entring Angle is without a good Defence, becauſe of the height of the Ramparts, and thickneſs of the Parapets, it's neceſſary that we inlarge thereupon, being a thing the moſt curious, and alſo the moſt neceſſary in the Art of Fortification.

In the firſt place it muſt be conſidered, that in the Side of *Fig.* 6. marked (1) that becauſe building the two Walls A C, and C B, in a re-entring Angle, the height of the Rampart, and thickneſs of the Parapet, which keep back the Soldiers behind, the Faces A C, and C B, ſo as they do not defend each other as they ought, and that the Enemy poſted in the Angle C, cannot be ſeen from any part, as has been ſhew'd before, they have been obliged to remedy this Inconvenience, to cut the Walls A C, aud C B in the Points D, and E; and from thence draw two Walls D F, and E G; the which being diſtant from the Point of the oppoſite Baſtion Musket-ſhot, can defend without any difficulty; the Faces A D and B E, alſo are leſs expoſed to the Cannon of the Enemy, and the two parts D F, and E G, which are called Flanks, muſt be joyned by the Wall G F, which is called the Courtain, becauſe in prolonging the Courtain F G, on the one part, and on the other it compaſſes a Body, half being on one ſide, *viz.* A D F H, and half on the other ſide, *viz.* B E G I; this Body is called a Baſtion; from thence one ought to conclude, the Flanks D F, and E G, ought not to paſs the Lines of Defence A G, and B F; for ſhould they be drawn to K and L, then a Cannon or Musket ſhot from L, cannot defend the Face of the oppoſite Baſtion A D; no more can the Face E B, be defended from the Point K: The firſt Defence then is A G and F B, from whence it is called, The Line of Defence, which ought not to be longer than 120 Fathoms.

In the part of the ſame Figure marked (2) where the two Demi-Baſtions B D E I, and C F G H are reformed, one ought to remark, that the Demi-Gorge I E and G H, remains the ſame; if one diminiſhes the Demi-flanked Angles I B D, and H C F, by the Lines B L and C K, the Faces B L and C K, become longer, but the Flanks L E and K G, become ſhorter than the Flanks D E and F G; but the Lines of Defence being ſhorter, as B O and C M, are ſhorter then B G and C E; that if one has no regard to the Demi-Gorge I E and G H, then the diminiſhing of the Demi-flanked Angles I B D and H C F, by the Lines B L O and C K M, leſſen the Vertue of the Flanks D E and F G, by the part cut off D L and F K; but if one adds thereto G O and E N, which are much more than what was cut off, the Flanks L N and K O, are much larger, but at the ſame time one augments the Lines of Defence; for as much as the Lines B O and C N, are longer than the Lines B G and C E; and moreover, the Demi-Gorges diminiſh, ſince the Demi-

Gorges P N and O Q, are much leſs than the Demi-Gorges I E aud G H.

From theſe Principles one may ſee the tract of the *Dutch* Method, which always makes the flanked Angle acute, and at the ſame time thoſe of the *Spaniards*, and ſeveral Modern Engineers, which often make the flanked Angle obtuſe; for by the obtuſe, the Demi-Gorge is augmented, and the Flanks, and the Faces, and the Lines of Defence diminiſhed; and by the Acute, the Flanks, and the Faces, and the Lines of Defence are augmented, and the Demi-Gorges diminiſhed.

But when that one would conſerve the Flanks and the Demi-Gorges taken at diſcretion.

For Example.

In the part of the ſame Figure marked (3) the Lines H E, F G, D E, A F, if one draws the Line of Defence from the Points F and E, by the Points D and A, or from the Points I and H, by the ſame Point D and A, the Lines F K and E L, become longer than the Lines H C and I B; but on the contrary, the Faces D C and A B, drawn from the Points I H, become

come longer than the Faces K D and L A, drawn from the Points E and F, and much leſſen the Terrain in thoſe Baſtions, it being plain that the Demi-Baſtions C D E H and B A F G, are larger than the Demi-Baſtions K D E H and L A F G; thus it is evident, that generally ſpeaking, the ſhorter the Lines of Defence are, having the ſame Courtains, the ſame Demi-Gorges, and the ſame Flanks, the more capable are always the Baſtions, and which make the flanked Angle become more acute.

The more the flanked Angle is acute, the more the flanking Angle is alſo acute. Thus in that part of the Figure marked (4) becauſe the Angles GEN and MFN, are more acute than the Angles G B O and M A O, the Angle E N F is more acute than the Angle B O A. Moreover, the more acute the flanked Angle is, the more Fire there is in the Courtain: Thus becauſe the Demi-point of the Baſtions G E K and M F I, are more acute than the Demi-Points of the Baſtions G B L and M A H, ſo are the Parts racing the Faces CE and D F, greater; parting from I and K in the Courtain, in room of the parts raceing the Faces D A and C B, parting from the Points H and L, conſequently the

Faces CE and FD, have each two Fires for their Defence on the one ſide DL and KL, which is the Flank and part of the Courtain; and on the other ſide C H aud H I, in lieu of which, the Faces BC and AD, have but the Flanks DL and CH for their defence.

The more acute the flanked Angle of the Baſtion is, the more it muſt be demoliſhed to make a Breach equal in the Point of the Baſtion, as in the part marked (5) in the ſame Figure, for to make the Breaches A B and C D equal, there muſt be more demoliſhed of the Angle G, than of the Angle E, for as much as G A and G B, are longer than E D and E C.

In the Parts of the ſame Figure marked (5 and 6) it is plain, that a Strait Courtain is the beſt of all others; that the curve Convex I K M, and the re-entering I L M, retrenches the Terrain of the Town, without being of any great uſe, and that the convex Courtain O Q S, and the Sailant O P S, hinders the Flanks N O and S R, from ſeeing and defending each other.

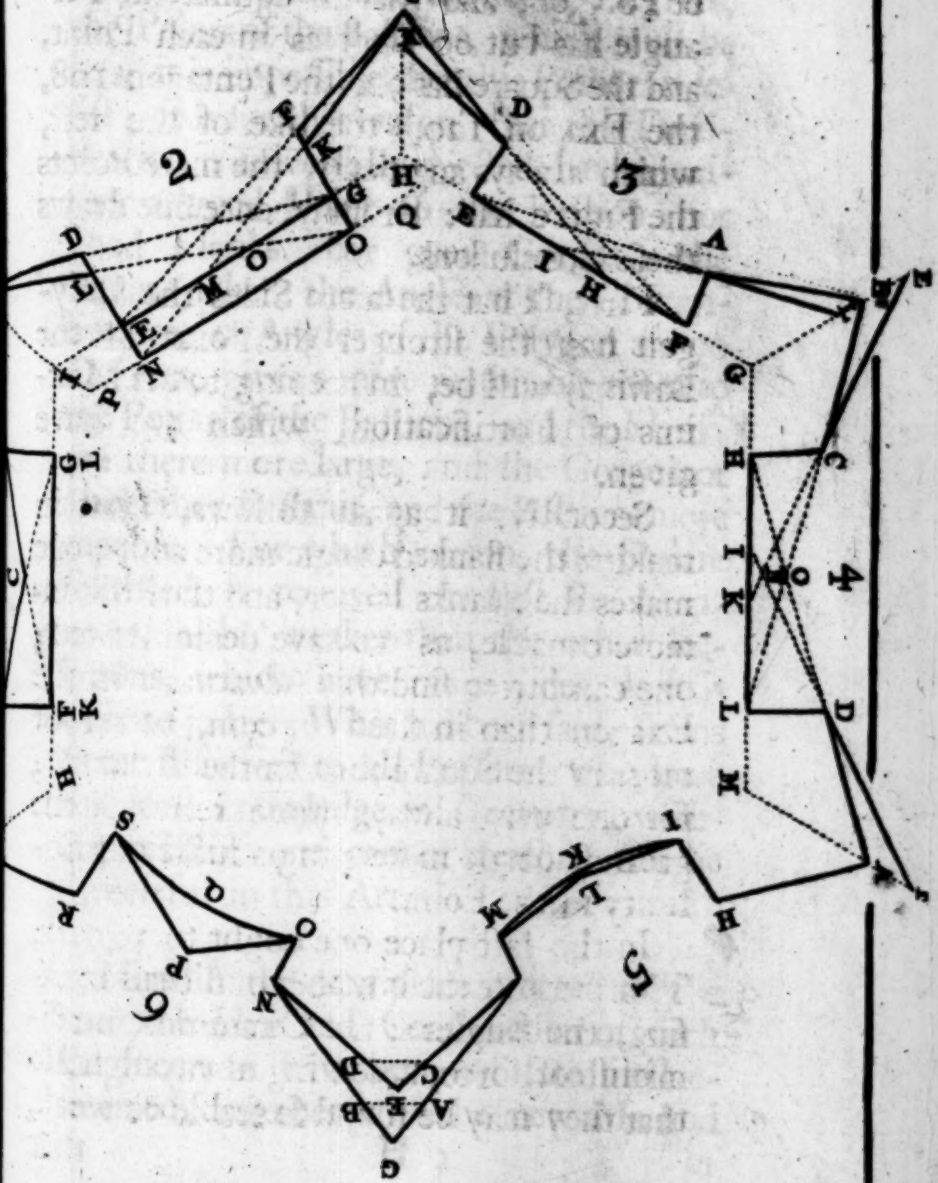
Again, The difference of Polygons makes a difference in the Point of the Baſtions, and largeneſs of the Flanks.

In the firſt place one ought to conſider, That the more Sides a Polygon has, the greater are the Angles at the Circumference or Polygon, and that an equilateral Triangle has but 60 Degrees in each Point, and the Square has 90, the Pentagon 108, the Exagon 120, the like of the reſt, which always augments, the more Points the Figure has: From whence one draws theſe Concluſions.

Firſt, That the more Sides the Polygon has, the ſtronger the Points of the Baſtions will be, in keeping to the Maxims of Fortification, which we have given.

Secondly, it again follows, That in making the flanked Angle more acute, one makes the Flanks larger, and the Baſtions more capable, as we have demonſtrated; one can better find this Advantage in the Exagon than in the Pentagon, better or more in the Square than in the Triangle; for one may always more retrench the greateſt Angle in keeping a ſufficient Solidity in the Point.

In the laſt place one ought to remark, That becauſe the Number of Sides decreaſing, the Angles at the Circumference diminiſh of force, becoming always leſs, ſo that they may be found ſo feeble or weak, that *age 98* **Fig. VI**


C
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that the Points of the Baſtions, which become again more little, cannot reſiſt a Cannon. Thus in a Triangle where the Angles at each Points are but 60 Degrees, the Points of the Baſtions, which muſt be leſs, it is impoſſible that this Point can reſiſt; it is for that reaſon, that this Fortification is univerſally rejected, having neither a good Point to the Baſtion, nor good Flanks, nor good Gorges; the Square where the Angles at the Circumference, or Angles of the Polygon are 90 Degrees, gives a more reaſonable room to the Points of the Baſtions, and the Flanks are there more large, and the Gorge not altogether ſo ſtrait, and the Baſtions more capable. For which reaſon, the Square fortified, is received amongſt the Engineers, altho' weaker than the other Polygons, which have more Sides, as it is eaſie to judge. What has been ſaid, ſeems to me ſufficient to all Perſons, who have the leaſt knowledge in *Geometry*, without which, one cannot reaſon, nor be ſucceſsful in this Art.

I ſhall in the next place proceed to give you the Idea and Conſtruction of ſuch Engineers as have been of late moſt eſteemed, together with the new Method of Monſieur St. *Julien*, lately publiſhed, which ſeems to me to be an extraordinary Method, and to which Ingenious Author I am indebted for many things in this Treatiſe.

CHAP. VIII.

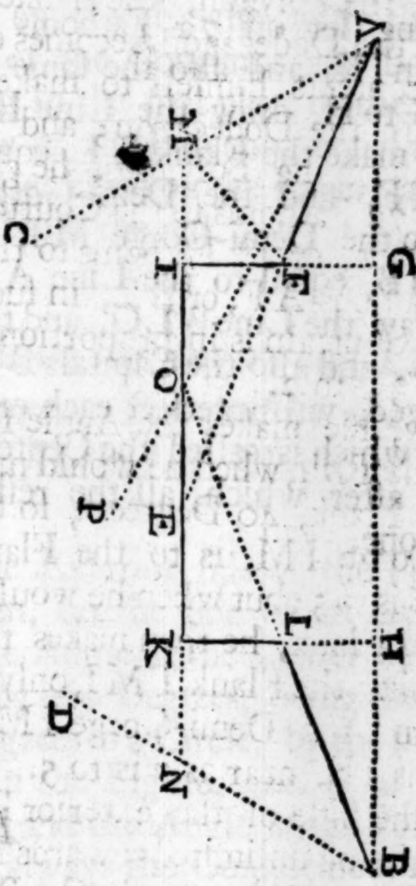
The Idea and Conſtruction of Marlois.

THIS Ingineer merits a particular Eſteem for having reformed the *Dutch* Method of Fortification, which was to make the Point of the Baſtion very acute, to the end not only to have very large Flanks, but alſo a ſecond Flank in the Courtain; this Method, if one takes not a particular care, leads into a very great Inconveniency; which is, That making the Ditch parallel to the Line of Defence, it arrives that the Flanks of the Baſtion do not diſcover all the Ditch: Moreover, making always the Flanks perpendicular to the Courtains, without Orillons, obliges to make the Embraſures too oblique, and the Batteries too much diſcovered.

Marlois, before he begins his Fortification, firſt finds the flanked Angle, by adding 15 Degrees to half the Angle of the Polygon, by which means, he makes the flanked Angle of the Square to be 60 Degrees, of the Pentagon 69 Degrees, of the Exagon 75 Degrees, of the Eptagon 79 Degrees 17 Minutes; by which continual adding of 15 Degrees to half the Angle of the Polygon, the flanked Angle after the Dodecagon becomes obtuſe; but he contents himſelf to make it 90 Degrees in the Dodecagon; and alſo in all the following Polygons, he gives 36 Rods, or 72 Fathoms to the Courtain I K, and 24 Rods, or 48 Fathoms to the Face of the Baſtions A F, or B L, in ſuch ſort, that the Courtain is in proportion to the Face, as 3 is to 2.

Laſtly, He makes the Angle forming the Flank TMI, when he would make but a ſimple Flank, 40 Degrees; ſo that the Demi-Gorge I M, is to the Flank I F, near as 6 is to 5; but when he would make a cover'd Flank, he then makes the Angle forming the Flank T M I, only 35 Degrees, and the Demi-Gorge I M, is to the Flank I E, near as 7 is to 5.

Let the Side of the exterior Polygon be A B, being unlimited towards B, make on the Point A, the Angle C A B, equal to half the Angle of the Polygon, which divide into 2 equal parts by the Line A P; make on the Point A, with the Line A P, the Angles P A E, of 7 Deg. 30 Min. with the Line Raceing A E; on the which place 48 Fathom for the Face A F, and from F, draw the Perpendicular on the Side of the exterior Polygon A B;



which lengthen'd at diſcretion, as G I, then on the Point F, make an Angle with the Line F I, of 50 Degrees, and from M, where the Line F M cuts the Line A C, draw the Line M N, parallel to A B, which will be the Side of the inward Polygon, when it ſhall be termined in N, which is thus done.

Having ſet off 72 Fathoms for the Courtain I K, and alſo the ſame diſtance from G to H, draw the Line H K, it's eaſie to make the Flank K L, equal to the Flank I F, and the Demi-Gorge K N, equal to the Demi-Gorge M I, and the Line H B, equal to the Line A G; and then draw the Line B L O, and the Capital B N, and alſo the Capitals B M being prolonged, will interſect each other in a Point, which is called the Center of the place; after which, all the reſt is eaſie to be done.

Remarks on the beforegoing Manner of Fortification.

This Manner of Fortification, gives us an eaſie Method to work on the Earth, where one can deſcribe a Regular Polygon on the Earth, with the firſt Draught of the Courtains and Baſtions, in making in the firſt place on the Earth, the Angle of the Polygon, equal to that which is deſcribed on the Paper, and afterwards finiſh the reſt.

To Calculate the Angles and Lines of a Polygon, Fortified by the aforegoing Method of Marloys.

Let the Exterior ſide of the Polygon A B given, be the ſide of an Exagon; ſo will the Angle of the Center be found by dividing 360 Degrees, being the number of Degrees in a Circle, by the number of Sides in the Figure, *viz.* 6 to be 60 Degrees; and the Angle at the Polygon, which is always the Complement of the Angle at the Center, to 180 Degrees, will be 120 Degrees, and by conſequence, the Demi-Angle of the Polygon B A C, is 60 Degrees, and the Demi-flanked Angle C A E, which is found by adding always 15 Degrees to the Demi-Angle of the Polygon, will be 75 Degrees, half of which is 37 Deg. 30 Min. which being ſubtracted from the Demi-Angle of the Polygon B A C, 60 Degrees, there remains 23 Degrees 30 Minutes for the diminiſhing Angle E A B.

Becauſe the Angle of the Flank F I K, is a Right-Angle or 90 Degrees, if one adds thereto the Diminiſhing Angle F E I, equal to E A B, or 22 Deg. 30 Min. the Sum ſhall be 112 Deg. 30 Min. the Angle of the Epaul A F I; from which ſubtracting the Angle I F M, which is 50 Degrees, there remains 62 Deg. 30 Min. for the Angle A F M: Therefore the Angle I F M, being 50 Degrees, the Angle I M F, muſt conſequently be 40 Degrees, being its Complement to 90 Degrees, and conſequently the Angle A M F, which is the Complement of the Sum of the two Angles C M I, equal to C A B, which is 60 Degrees, and I M F, which is 40 Degrees, *viz.* 100 Degrees to 180 Degrees, will be found to be 80 Degrees. Thus are all the Angles found.

As for the Lines there are only known the Face A F, 48 Fathoms, and the Courtain I K, 72 Fathoms, by which, the Angles being known, one may find the Lines.

And Firſt, In the Oblique Triangle A M F, the Capital A M, and the Line M F, by the following Proportions, may be found.

Firſt, For to find the Capital F M.

		Co. Ar.
As (*s*) of the Angle A M F	80:00	0.0066485
Is to the Face A F	48 Fa.	1.6812412
So is (*s*) of the Angle A F M	62:03	9.9479285
To the Capital A M	43.2 Fa.	1.6358182

Secondly, To find the Line F M.

As (*s*) of the Angle A M F——	80 : 00—	0.0066485
Is to its Oppoſite Side A F——	48 Fa.—	1.6812412
So is (*s*) of the Angle F A M—	37 : 30—	9.7844471
To its Oppoſite Side M F———	29.6 Fa.-	1.4723368

One may find the Flank I F, and the Demi-Gorge M I, in making in the Right-angled Triangle F M I, the two following Proportions.

Firſt, To find the Flank I F.

As Radius———	90 : 00—	10.0000000
Is to the Line F M--	29.6 Fa.-	1.4712917
So is (*s*) of the Angle forming the Flank I M F	-40 : 00—	9.8080675
To the Flank I F——	19 Fa.—	1.2793582

Secondly, To find the Demi-Gorge M I.

As Radius———90 : 00—10.0000000
Is to the Line M F—29.6 Fa. 1.4712917
So is (*s*) of the Angle I F M——— } 50 : 00— 9.8842540

To the Demi-Gorge M I— } ——-22.6 Fa. 13555457

Which being found to be 22 Fathoms and near 4 Feet, the double of which is 45 Fathoms 2 Feet, which being added to the Courtain I K, which is 72 Fathoms; one will have 117 Fathoms and 2 Feet, for the Side of the Interior Polygon M N.

Then to find the Side of the Exterior Polygon A B, one muſt firſt find the Line A G, in the Triangle A G F, the Right Angle at G, by the following Proportion,

As Radius————90 : 00—10.0000000
Is to the Face A F—48 Fa.— 1.6812412
So is (*s*) of the Angle A F G— } -67 : 30— 9.9656153

To the Line A G-44.3 Fa.— 1.6468565

Which being found to be 44 Fathoms, and near 2 Feet, the double of which, is 88 Fathoms and 4 Feet, which being added to G H equal to I K, which is 72 Fathoms, will give 160 Fathoms 4 Feet for the Exterior Side of the Polygon A B.

For to find the Second Flank E K, one muſt firſt find the Complement E I, in making in the Right-angled Triangle E I F, the following Proportion,

As Radius————90 : 00—10.0000000
Is to the Flank I F—19 Fa.—01.2787536
So is the (*t*) of E F I-67 : 30—10.3827757

To the Complement of the Second Flank E I- } -45.8 Fa.- 1.6615293

Which being found to be 45 Fathoms, and near 5 Feet, being ſubtracted from the Courtain I K, 72 Fathoms, the Remainder will give 26 Fathoms, and 1 Foot, for the Second Flank E K or I O.

CHAP.

CHAP. IX.

The Idea and Conſtruction of Chevalier de Ville.

THIS Author makes, as much as he can, the Point of his Batteries to be 90 Degrees, as the moſt ſolid; his Orillons have at leaſt half the Flank in length, and are 6 Fathoms long; this he makes for the better covering his Batteries, but as he makes his Demi-Gorge but the ſixth part of the Interior Polygon, by which means he renders his Baſtions ſo ſtrait, as not to be capable of good Intrenchments; ſo his Flanks being always Perpendicular to his Courtain, one may eaſily judge, that his Batteries ought to be placed very obliquely to well defend all the Counterſcarp, and the rather becauſe of the exceſſive length of the Orillons.

After having deſcribed a Circle on your Paper, divide it into as many equal parts as you will have Sides in the Figure; (for *Example* 6. as in *Fig.* 8.) then divide the Side A B into 6 equal parts, and take one of them for the Demi-Gorges B C, A D, and B C and A G, and draw the Flanks C F, D E, and G H, perpendicular to the Sides of the Polygon, of the ſame length as the Demi-Gorges, draw the Line H E, and take in your Compaſſes the half thereof, K E or K H, and place the ſame on the Capital from K to I, ſo ſhall the Point I, be the Point of the Baſtion; from which Point, if you draw the Lines I E and I H, you will have the two Faces, and the firſt Draught of the Baſtion will be finiſh'd.

As for the Flanks, they muſt be covered with Orillons, which are thus formed: Divide the Flank E D, into two equal parts, in the Point O; and laying a Ruler on the Point of the oppoſite Baſtion P, and on the Point O, draw the Line P O; then ſet off 6 Fathoms from O to N, and from the Epaul on the Face, prolonged from E to L, the like of the reſt; then draw the two Lines L N and R Q; ſo are the Orillons finiſhed, when one would have 'em Square; but when one would have it

Round, with the Diſtance R Q; from R and Q, deſcribe the two Arches, which interſect one the other in the Point M; then from M, with the Diſtance M Q or M R, deſcribe the Arch R Q, which divide into two equal parts in the Points S; and from S, with the diſtance S R or S Q, ſweep the Arch which ſhall finiſh the Round Orillon.

He makes his Parapet of 3 Fathoms, with a Terraſs of 7 or 8 Fathoms comprising the Parapet.

☞ Here Note, *That in making the Orillons, we have ſomething deviated from the common Method of this Author, who gave two thirds of the Flank to the Orillon, as is done in the Side of the Polygon* BY, *where one third of the Flank, or Demi-Gorge, is ſet off from* n *to* m, b *to* f, a *to* d, f *to* e, *from* k *to* m, *and from* h *to* l, *and draw the Line* h k *and* d e, *which (in my Opinion) renders his Cazemats too little, and his Cannon therein are too much cooped in to well defend the Counterſcarp.*

Remarks

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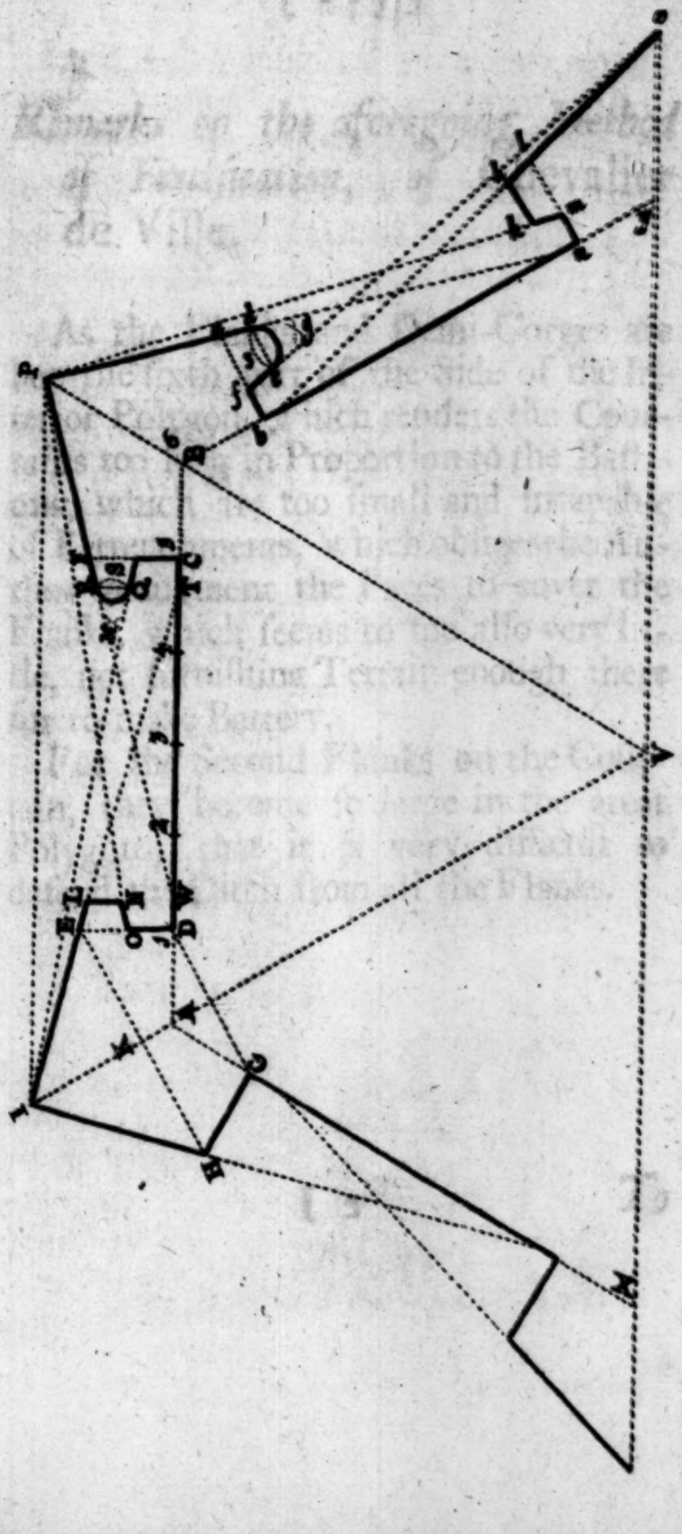
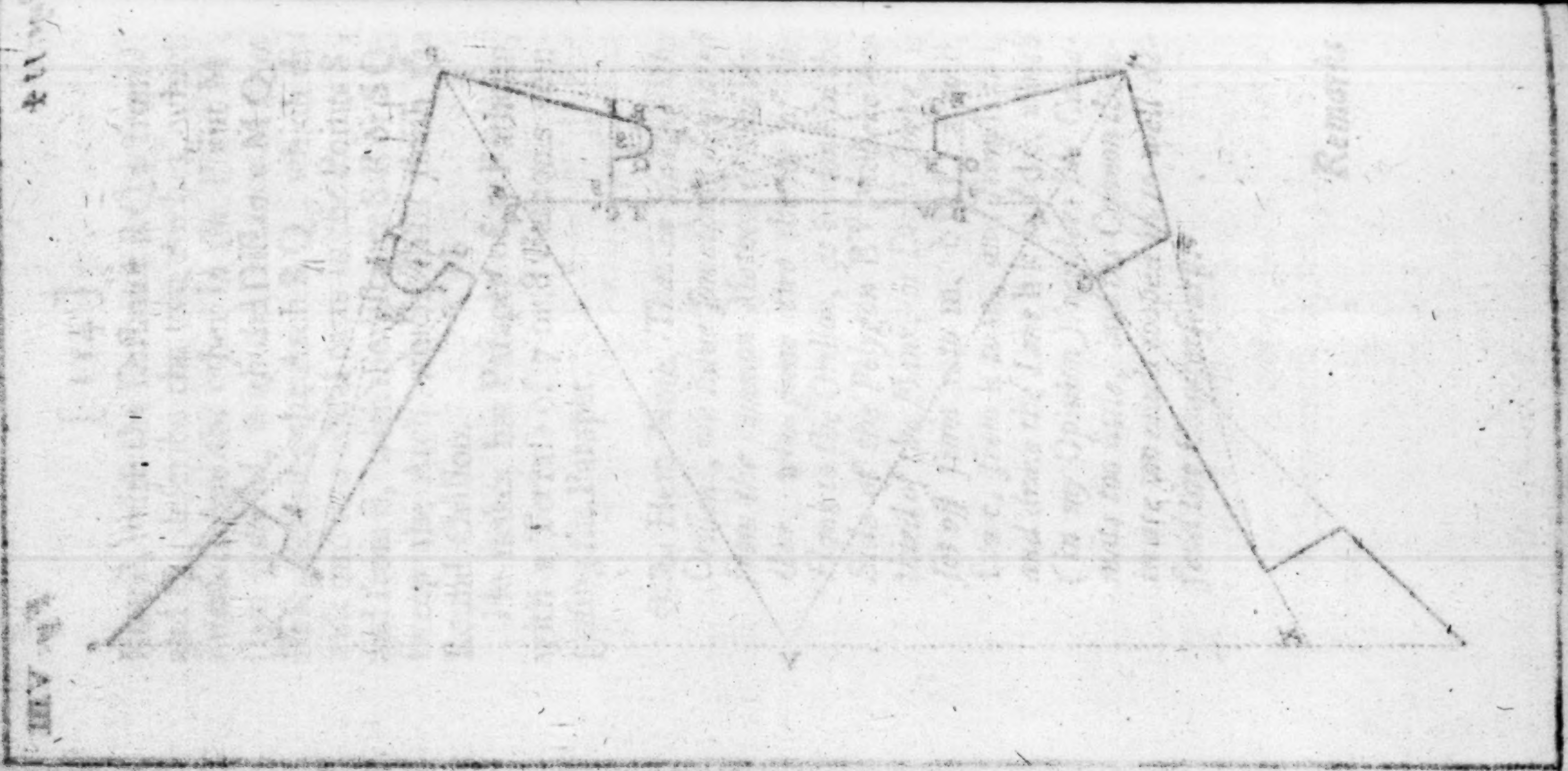
Fig: VIII





Remarks on the aforegoing Method of Fortification, of Chevalier de Ville.

As the Flanks and Demi-Gorges are but the ſixth part of the Side of the Interior Polygon, which renders the Courtains too long in Proportion to the Baſtions, which are too ſmall and incapable of Retrenchments, which obliges the Author to augment the Faces to cover the Flanks, which ſeems to me alſo very little, not furniſhing Terrain enough there for to make Battery.

For the Second Flanks on the Courtain, they become ſo large in the great Polygons, that it is very difficult to defend the Ditch from all the Flanks.

To Calculate the Lines and Angles according to the aforeſaid Method of Chevalier de Ville.

BEcauſe *Figure* 8. is an Hexagon, the Angle at the Center A V B, will be found by Dividing 360 Degrees by 6, the Number of Sides to be 60 Degrees; and the Angle at the Figure or Angle of the Polygon X A B, will be found by ſubtracting the Angle at the Center, from a Semi-circle, or 180 Degrees, to be 120 Degrees; ſo that conſequently the Demi-angle of the Polygon V A B, is 60 Degrees, and becauſe the Flanks here are perpendicular to the Courtain, the Angle of the Flank E D B, is 90 Degrees; and becauſe the flanked Angle H I E, is alſo a Right-angle, the Demi-flanked Angle A I E, is conſequently 45 Degrees; and the Diminiſhed-Angle I T D, equal to the Angle TIP, which is the Complement of the Demi-flanked Angle A I T, which is 45 Degrees, to the Demi-Angle at the Figure V A B or V I P, which is 60 Degrees, will be 15 Degrees, and the Angle of the Epaul I E D, which is found by adding 15 Degrees to the Angle of the Flank E D B, which is 90, is 105 Degrees.

Suppoſe then the Side of the Interior Polygon A B, be 120 Fathoms, conſequently then the Flanks E D and F C; alſo the Demi-Gorges A D and C B, will be each 20 Fathoms, which is the ſixth part of 120, and the Courtain D C, will be 80 Fathoms; and the prolonged Courtain A C or B D, will be 100 Fathoms.

Thus in the Iſoſcele Triangle G A D is enough known; for if one ſubtracts the Angle of the Polygon G A D, which is 120 from a Semi-circle, or 180 Degrees, there will remain 60 Degrees for the Sum of the two Angles A D G, and A G D; and becauſe the Sides A D and A G, are equal, thereſore are their oppoſite Angles; ſo likewiſe, therefore half of 60 Degrees, which is 30 Degrees, is the quantity of each of the Angles at the Baſe A G D, or A D G, which are always equal to half the Angle at the Center A V B.

Thus one may find in the Triangle A D G, the Line of the Gorge G D, or the Capital A I, by the following Proportion, which our Author ſeems unacquainted with.

As (*s*) of half the Angle of the Center————	30:00—0.3010299
Is to the Flank of the Baſtion ——	20 Fa.—1.3010300
So is (*s*) of the Angle of the Center	60:00—9.9375306
To the Capital A I-34.6 Fa.—	1.5395905

So that the Capital A I, is 34 Fathoms 4 Feet, near.

In the Oblique Triangle A I T, one may find the Line Raceing I T, and the Line A T, by the following Proportions.

As (*s*) of the diminiſhed Ang. ATI	15:00—0.5870038
Is to the Capital A I-34:6 Fa.	1.5390761
So is (*s*) of the Demi-angle of the Polygon VAB--	60:00—9.9375306
To the Line Raceing I F,————	115.7 Fa. 2.0636105

As (*s*) of the diminiſhed Angle ATI } 15:00—0.5870038
Is to the Capital A I—34:6 F.–1.5390761
So is (*s*) of the Demi-flanked Angle A I T——— } 45:00—9.8494850

To the Line A T—94.5Fa.–1.9755649

So that the Line A T, is found to be 94 Fathoms and 3 Feet; from which ſubtracting the Demi-Gorge A D, which is 20 Fathoms, there will remain 74 Fathoms and 3 Feet for the Complement D T; the which being ſubtracted from the Courtain D C, or 80 Fathoms, there will remain 5 Fathoms 3 Feet for the ſecond Flank T C, which otherwiſe may be found by finding the Complement DT, in the Right-angled Triangle EDT, independently of the Capital AI, which is ſufficient to ſhew, that the Capital A I, is equal to the Gorge Line G D, of which the Geometrical Demonſtration is very eaſie.

As Radius	09:00	10.0000000
Is to the Flank E D	20 Fa.	1.3010300
So is (*t*) of the Angle T E D	75:00	10.5719475
To the Complement D T	94.6	1.8729775

Which is found, as before, 94 Fathoms 3 Feet, *&c.*

CHAP. X.

The Idea and Conſtruction of Count Pagan.

THIS *Author*'s Deſign in his Fortification, is to keep the Enemy, by ſeveral Works placed one before another, far from the Body of the Place, thus: One finds therein a little Baſtion, which has before it a larger, which ſerves as its Counter-guard; and beyond the Ditch of which, is another Counter-guard with its Ditch. The Ravelin which he makes before the Courtain, is double; the one being placed before the other, to hinder the Approach; and below all that he makes a Tenail in the Ditch over againſt the Courtain, where he places part of the Musketeers. It is certain, that all theſe Works placed one before the other, require a double pain to the Beſiegers to render themſelves Maſter of them: The Points of the Baſtions are little conſidered by this Ingineer, who admits them all indifferently, provided that they are of a reaſonable Solidity, all his aim being to render a Baſtion capable of a large Terrain, and above all of three Batteries of Cannon, which he places therein raiſing one behind the other, his Flanks being intirely oppoſite to thoſe of *Errad*, falling perpendicular on the Line of Defence, and not on the Face of the oppoſite Baſtion; this he doth for to ſhoot more directly on the Covert-way, and to command the Glacis.

This *Author* has eſtabliſhed three ſorts of Fortification, *viz.* The Great, the Little, and the Middle; he fortifies by the Exterior Polygon, which he makes each ſide to be 200 Fathoms in the Great Fortification, 180 or 164 Fathoms in the Middle, and 160 Fathoms in the Little; he gives 60 Fathoms to the Face in the Great, 55 or 50 Fathoms 5 Feet 4 Inches in the Middle, and 50 in the Little: Laſtly, The Perpendicular determining the Line Raceing, is always 30 Fathoms, except in the Square, where it is 27 Fathoms in the Great Fortifications, and 24 Fathoms for the Middle and Little.

Otherwiſe, If there be given two Tenths of half the Side of the Exterior Polygon to the Perpendicular, ſix Tenths of half the Side of the Exterior Polygon to the Face, according to the following Conſtruction, will ſerve for all Polygons, except the Square, where the Perpendicular is made ſomething leſs than in the other Polygons, *viz.* by a Tenth part.

Having deſcribed a Circle on your Paper, and made a Polygon of as many Sides as you will have it, (for Example an Hexagon, as in *Fig.* 9.) and having divided the Side A B, into two equal parts, in the Point C, draw from thence to the Center V, the Line C V, which ſhall be Perpendicular to the Side A B; then divide A C, into 10 equal Parts; then take with your Compaſſes 3 of the ſaid 10 parts, and place them on the Perpendicular from C to D, and draw from the Points A and B through the Point D, the Lines A D F and B D K, of any convenient length, and from the Point A and B, place 6 of the ſaid 10 parts for the two Faces A H and B G; and draw from the Points H and G, Perpendiculars to the Lines of Defence A F and B K, and you will have the two Flanks H K and G F, which muſt be joyned by the Courtain K F.

Otherwiſe, Having ſuppoſed the Exterior Side of the Polygon A B, 200 Fathoms for the Great Fortification, 180 for the Middle, and 160 for the Small, divide it into two equal parts in the Point C; and and draw from the Point C, to the Center V, the Perpendicular C D of 30 Fathoms, in all the Polygons, except the Square, where you muſt make it only 27 Fathoms for the Great Fortification, and 24 for the Middle, and Small: Draw by the Point D, the Lines of Defence A D F, and B D K, and thereon place, from A and B, for the Face A H and B G, 60 Fathoms for the Great Fortification, 55 for the Middle, and 50 for the ſmall: Laſtly, Draw the Flanks H K and G F, perpendicular to the Lines raiſing A F and B K, and joyn them by the Courtain F K.

For the Cazemats and Orillons, divide the Flanks into two equal parts in the Point L, and the Line H L ſhall be the Face of the Epaul or Orillon, which this *Author* makes Square; prolong the Line of Defence within the Baſtion towards N, and draw from L the Line LO, parallel to the ſame Line of Defence, for the Enforcement of the Cazemat; or, which, in my Opinion, is much better, draw from the Point of the oppoſite Baſtion B, thro' the Point L, the Line BLO, as you ſee done here, of a convenient length, within the Baſtion, for the Enforcement of the Cazemat, and between the Lines L O and KN, having at firſt drawn back 5 Fathoms on each of them, from L and K, make 3 Parapets, and 3 Places for the Cannon, the one behind the other, giving 3 Fathoms to each Parapet, and 4 Fathoms for each place, for the Cannon to recoil in; afterwards the Line N O being prolonged 3 Fathoms unto P, draw the Line P Q, parallel to the Face of the Baſtion A H, and you will have the firſt Draught of Count *Pagan*, which muſt be fortified every where with a Parapet of 3 Fathoms, and 7 Fathoms for the Terraſs, including the Parapet; as for the 3 Batteries in the Flank, he makes the firſt next the Ditch 2 Fathoms above the Bottom of the Ditch, and the Middle Battery 4 Fathoms high, and the third and laſt 6 Fathoms high above the Bottom of the Ditch, being of the ſame height with the Rampart, the which is 3 Fathoms above the Level of the Campaign, the Depth of the Ditch being alſo 3 Fathoms below.

This is eaſie to apprehend by the Profile of theſe Batteries, which I have deſcribed on the length of the Wall of the Demi-Gorge, on the prolonged Line of Defence, where the Line A B repreſents the Walk or Terre-plain of the Rampart, and of the higheſt Battery, of which, CD is the Parapet; the Line E F repreſents the Terre-plain of the Middle Battery, of which H G is the Parapet; the Line I K repreſents the Terre-plain of the loweſt Battery next the Ditch, of the which, the Parapet is L M; laſtly, N O repreſents the Bottom of the Ditch.

The Little Baſtion Q P N, hath its Rampart and Parapet the ſame thickneſs with the reſt, which ſerves for a Retrenchment, and is formed of the Earth which is taken from the little dry Ditch next it, P T V; this little Baſtion alſo ſerves for a Cavalier, as has been ſaid before.

The Great Ditch is 16 Fathoms wide, traced by 2 Lines, parallel to the Face of the Baſtions and Lines of Defence.

Beyond which he makes a Counterguard, which is made by drawing a Line parallel to the Counterſcarp of the Ditch, 25 Fathoms from it, the thickneſs of the Rampart and Parapet, which is the ſame with the others, *viz.* 7 Fathoms for the whole; the Flanks of which Counterguard has 3 Batteries, as well as thoſe of the Baſtions, and can contain 3 Cannons in one, 4 in another, and 2 in another, in all 9 Pieces. The Ditch, which he makes beyond the Counter-guard, he makes 12 Fathoms wide on the re-entring Angle, of which he makes a Ravelin or Demi-Lune, the Demi-Gorges of which he makes each 20 Fathoms, and each Face 34 Fathomss, the Rampart and Parapet of which, is the ſame with the reſt; its Ditch he makes 10 Fathoms, the Faces of the Demi-Lune prolonged, marks out the length of the Faces of the Baſtions of the Counter-guard, the Flanks of which are drawn perpendicular to its Lines of Defence, the Batteries of which are formed in every reſpect, as thoſe of the Baſtions of the Baſtions of the Body of the place; the Covert-way he makes 4 Fathoms broad, with its Banquet, and Parapet, and Glacis, as others, all which is repreſented in that part of *Fig.* 9. compleat, marked (1.)

This Method of Count Pagan *ſeeming to be the Model of all the reſt of the Methods of Fortification that have been ſince publiſhed, I have added another Method to lay down the ſame.*

Figure 9.] Having divided the Side of the Exterior Polygon A B, into two equal parts in the Point C, as before; from the Point C, draw the Perpendicular C D, equal in length to one third part of half the Side of the Exterior Polygon A C or B C, and from A and B, by the end of the Perpendicular D, draw the Lines A D F and B D K; then take a third part of A D or B D, and place it from D to F and K, ſo have you the Complements of the two Lines of Defence; then joyn F K by the Right-line K F, for the Courtain, and on the Point K and F, draw the two Lines K H and F G, perpendicular to the Lines of Defence B K and A F; then if you divide the Flank H K, into two equal parts in the Point I, H I will be the Epalement of the Baſtion, and I K the largeneſs of the inforced Flank: Then divide the Flank H K or F G, into 3 equal parts, and one third thereof will mark out the

Diſtance of the Parapets of the inforced Flanks, which muſt be always parallel between themſelves, and perpendicular to the Line of Defence prolonged; then if from the Extremity of the uppermoſt third part of the Flank, you draw a Line parallel to the prolonged Line of Defence KN, it will cut the Line NO in the Point P: Then from P draw the Line PQ parallel to the Face AH, you will mark out the inward Baſtion QPN; then if behind the Faces of the Baſtions, Flanks and Courtain, you draw Parallels diſtant therefrom one third of the length of the Flank HK or GF, it will give the thickneſs of the Rampart, on the third part of which muſt be placed the Parapet, as uſual; then divide the Face of the Baſtion AH or BG, into 3 equal parts, and take one of thoſe parts for the breadth of the Ditch, at which diſtance draw the Counterſcarp parallel to the Faces of the Baſtions, making a re-entring Angle towards the middle of the Courtain; then if from that re-entring Angle on the Counterſcarp you place on each ſide half the Courtain, it will give the Demi-Gorge of the Demi-Lune, forming an Angle next the Campaign, and if with the Diſtance equal to half that Demi-Gorge, from the Demi-Lune; you draw two Lines parallel to its Face, you will have the Interior Demi-Lune; then if behind the Faces of the one and the other Demy-Lune, you draw parallel Lines diſtant therefrom, equal to the fourth part of the Demi-Gorge, you will have the thickneſs of their Ramparts, on which the Parapets muſt be raiſed as uſual; then take half of the Demi-Gorge for the breadth of the Ditch of the Demi-Line, and at that diſtance draw its Counterſcarp parallel to its own Faces; then with the ſame diſtance draw Lines parallel to the Ditch of the Place, and you will form the Counter-guards, making an Angle like to that of the Baſtions of the Place; the two ſides of which, muſt be prolonged unto the Ditch of the Demi-Lune. The Ramparts, Parapets and Ditch of which Counter-guards, muſt be the ſame as that of the Demi-Lune; All which is repreſented in *Plate* IX. in that part of the compleat Figure mark'd (2.)

If you follow the ſame Rule, and obſerve the ſame Maxims on all Exterior Sides of your Polygons, you will have the Place exactly drawn, according to Count *Pagan*'s Method, be the Sides of the Polygon or Lines of what length ſo-

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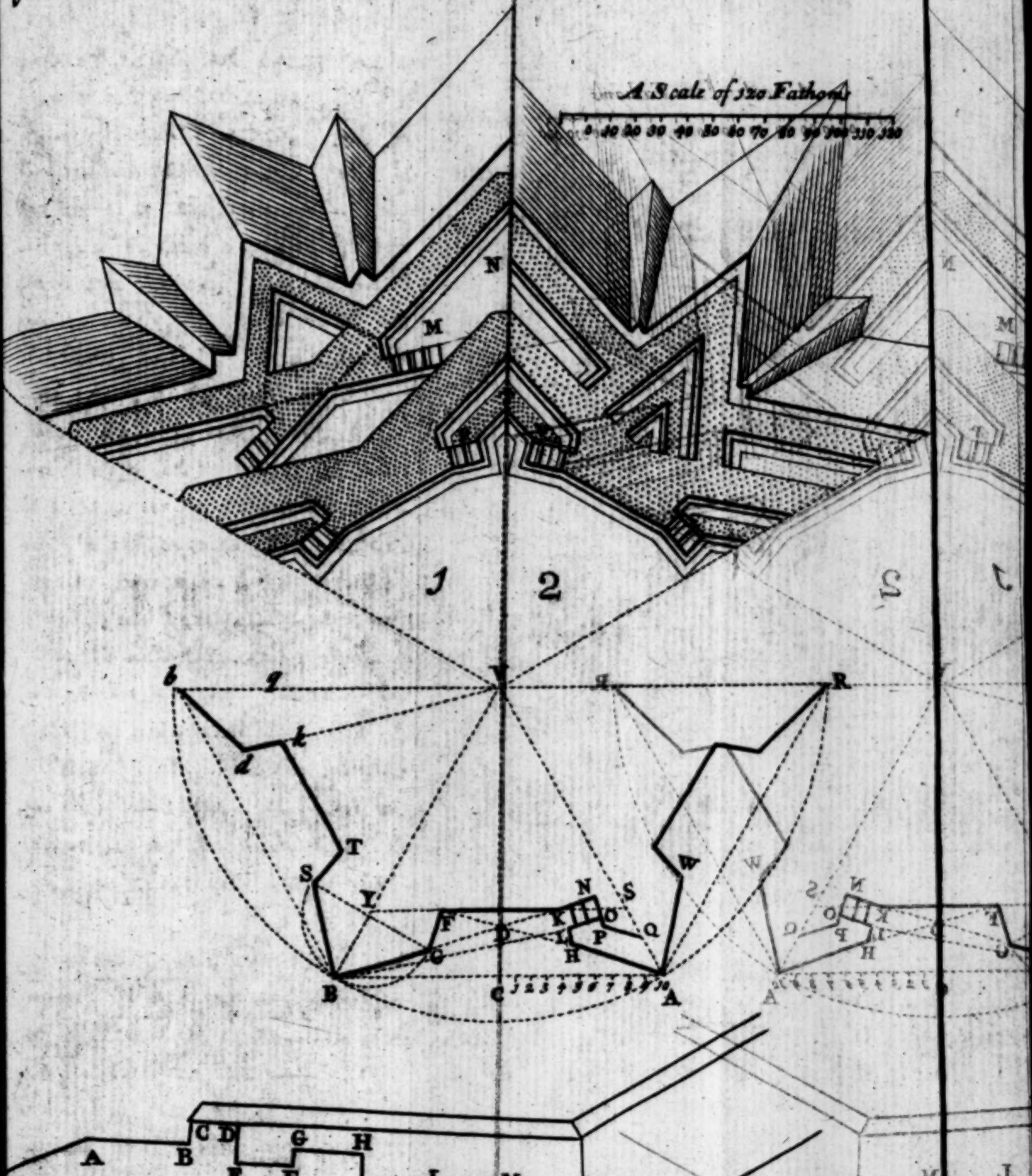
Fig. IX



ever; but the Perfection of thoſe Fortifications, are thoſe in which the Exterior Polygon is 180 Fathoms.

Remarks on the aforegoing Method of Count Pagan.

This Diviſion of Count *Pagan*, of Great, Middle and Small Fortification, ſeems to me of little conſequence in Regular Fortification; therefore I ſhall content my ſelf to ſpeak here of the middle ſort, which gives 180 Fathoms for the Side of the Exterior Polygon, where the Line of Defence is found near 126 Fathoms, as you will find in the Calculation thereof, which we ſhall give you, having firſt ſaid ſomething of the Advantages and Diſadvantages of this Method of Fortification, which has ſerved as a Model to all others that have been invented ſince this has been publiſhed.

This *Author*, conſidering that the principal Parts which ſtrongly defend, and a long time hinder the taking of Places, are the Flanks, the Ramparts, and the Ditch, made the Flanks very large, and the Gorges very long, for to make there 3 Batteries, in each of which he puts 4 Pieces of

Cannon, of which 3 are well enough covered, ſo that they cannot eaſily be incommoded by the Counter-Batteries of the Enemy, whilſt they themſelves will be extreamly incommoded thereby, when they appear to lodge themſelves in the Ruins of the Breaches, where the Cannons of theſe Batteries batter from Reverſe.

The 2 Ditches with the 2 Ramparts, which this *Author* conſtitutes by his Maxims, not only hinder the Beſiegers for to paſs the Ditch with eaſe, but alſo keep them from making uſe of their *Furneaux**, the means for to lodge themſelves on the Ruins of the Breaches: Moreover, the Aſſailants being once rendred Maſter of the firſt Rampart, will find themſelves ingaged in the ſecond Ditch almoſt in the middle of the Beſieged, who can eaſily batter them from all Sides, and incommode them with their Bombs and Granadoes, or otherwiſe with the † *Gauderons*, the Mines, and with the *Fourneaux*, &c.

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* *A ſmall Chamber of a Mine, in form of a Cube.*

† *A ſort of Fire Works made of little Facines dip'd in a Compoſition of New Wax, Pitch, Colophane, to fling into the Ditch to burn the Galleries.*

Laſtly, The Ditch is defended as well as is poſſible, from the Flanks, which being perpendicular to the Line of Defence, flanking the full Face of the oppoſite Baſtion, and the largeneſs of the Demigorge, ſhortens the Line of Defence; which is the reaſon, that the higheſt part and the middle will never be more than Musket-ſhot diſtance at leaſt, in the Middle Fortification, which ought conſequently to be prefer'd before the Great.

Theſe Advantages, and many more, are the reaſon that many approve of this Method of Fortification, of which number was that moſt Ingenious Prince and Great Mathematician, King *CHARLES the Second*, that Prince having framed Proportions for to fortifie by the Interior Polygon, which are inſerted in Sir *Jonas Moor*'s Fortification. But this Method, tho' Excellent in the General, is not, I am perſwaded, without Diſadvantage; *viz.*

Firſt, The Faces appear to me to be too long, giving too much room thereon for the Enemy to make great Breaches, which will ſtrangely incommode the Beſieged to repair them, and to hinder the Attackers from lodging themſelves therein, particularly when the Garriſon is but ſmall.

The

The Cazemats and the Flanks ſeem to me to be too much expoſed to the Counter-Batteries of the Enemy, who can eaſily diſmount the Cannon, and afterwards get over the Ditch, and hide themſelves in the Breach, without fearing the Muſketeers in the oppoſite Flank, who are there to far off in the Great Fortification; beſides which, the Cannon hid is not ſufficient to hinder the Enemy from lodging themſelves in the Ruins of the Breach; becauſe, before one can Charge the Pieces again, the Enemy can enter therein, and raiſe Empaulments to cover themſelves.

The Flanks perpendicular to the Line raceing, this *Author* ſuſtains for Reaſons which makes them otherwiſe; not conſidering, that that which ſees, is alſo ſeen from that which it regards; and conſequently that they may be rejected by the ſame Principles by which they have been eſtabliſhed; for that which ſees, is really ſeen by that which it regards; and that which ſees a great compaſs, is alſo ſeen from that large compaſs, in the which the Beſiegers may find an advantageous part for placing their Batteries to diſmount thoſe which are ſeen in the Flanks, too much expoſed: Moreover it is not neceſſary that the Pieces in the Flanks ſhould diſcover ſo great a compaſs in the Campaign, their Office being no other than to defend the Eace of the Baſtion, the Ditch and the oppoſite Counterſcarp, the reſt may be defended from many other parts.

Laſtly, The Retrenched Baſtions, which very much augments the expence, as well as trouble, it being but a Retrenchment, and void, may be as eaſily taken, as the firſt part, by the means of a Second Mine, and by its loſs, cauſe that of the place; without the Beſieged being able to hinder it, or in ſuch extremity to raiſe any Intrenchments in that void Baſtion, to make a more advantagious Capitulation.

Theſe Reaſons appear to me ſufficient to ſhew, that as this manner of Fortification is excellent in the greateſt part of its Maxims, ſo it is certain, that in reſerving what part thereof is good, and in repairing the things which are diſadvantagious, we may from thence form a Method of Fortification altogether perfect.

For Example.

To the end that the Cazemats be longer and better covered, inſtead of drawing the retiring of the Flank L P, parallel to the Line of Defence, it may be drawn from the Point of the oppoſite Baſtion, as I have done here.

And becauſe the flanked Angle begins to be obtuſe in the Heptagon, and becomes extreamly open in the Polygons, which have more Sides, (which is, in my Opinion, a conſiderable defect) one may correct this Angle by making it right, by means of a Semi-circle deſcribed on the 2 Flanks of the Baſtion (as you ſee repreſented *Fig.* 10. by the Circle GBS) which will render the Face a little longer; but that defect is not conſiderable, in regard the Right-Angle flanked of the Tenail, better reſiſts; and for the ſecond Flank, which it makes on the Courtain, it very much augments the Defence of the Place.

Laſtly, Inſtead of drawing the Flanks at Right-Angles, with the Line of Defence, they will be better drawn from the Center of the Place, as you ſee done in the Demi-Baſtion *k d b q*; by which means the Flank will not only be leſs expoſed, but will alſo become ſomewhat larger.

To Calculate the Lines and Angles, according to the aforegoing Method of Count Pagan.

The Side of the Exterior Polygon A B, belonging to an Hexagon, the Angle at the Center A V B, will be 60 Degrees, and the Angle of the Polygon R A B, 120 Degrees; and if one ſuppoſes the Side of the Exterior Polygon A B, to be 180 Fathoms, ſuch as it ought to be in the Middle Fortification, which we here follow, the half thereof A C or B C, will be 90 Fathoms, the Perpendicular C D, 30 Fathoms, and the Face A H or B G, 55 Fathoms; by the means of which Lines and Angles, thus known, may eaſily be found by Calculation, the other Angles and Lines.

And firſt, The diminiſhed Angle C A D, may be found by making in the Right-angled Triangle A C D, the Right-Angle at C, the following Proportion.

Co, Ar.
As the Side A C——90 Fa.— 8.0457575
Is to Radius————-90:00—10.0000000
So is the Side C D——30 Fa.— 1.4771213

To (*t*) of the Angle C A D—— } 18:26—— 9.5228788

So that the Diminiſhing-Angle C A D, being found to be 18 Degrees 26 Minutes, if you ſubtract it from the Demi-Angle of the Polygon V A C, 60 Degrees, there will remain 41 Degrees 34 Minutes, for the Demi-flanked Angle V A H; therefore the flanked Angle W A H, will be 83 Degrees 8 Minutes; to the which, adding the Angle of the Center A V B, or 60 Degrees, you will have 143 Degrees 8 Minutes, for the flanking Angle A D B.

For to find the Flank H K, you muſt firſt find the Hypothenuſe A D, of the Triangle A C D, by the following Proportion.

As Radius-	90:00-	10.0000000
Is to the Side A C--	90 Fa.—	1.954242
So is (ſ) of the Angle C A D—	---18:26—	10.022875
To the Hypothenuſe A D—	-94.8 Fa.—	1.977117

Which being found to be 94 Fathoms, and near 5 Feet; if you ſubtract therefrom the Face A H, or 55 Fathoms, there will remain 49 Fathoms and 5 Feet, for the Hypothenuſe D H, of the Triangle H D K, in which the Angle H D K is equal to double the Diminiſhed-Angle C A D, or 18 Degrees 26 Minutes, and conſequently is 36 Degrees 52 Minutes. Thus you may find the Flank H K, by the following Proportion.

As Radius	-90:00—	10.000000
Is to the Hypothenuſe D H—	39.8 Fa.-	1.599883
So is (s) of the Angle H D K—	36:53—	9.778119
To the Flank H K—	23.8 Fa.-	1.378002

Which is found to be 23 Fathoms, and near 5 Feet.

If to the Angle H D K, or 36 Degrees 52 Minutes, be added the Angle H K D, or 90 Degrees, the Sum will give 126 Degrees 52 Minutes, for the Angle of the Epaule A H K, and if the Diminiſhed-Angle C A F, equal to H F K, or 18 Degrees 26 Minutes, be added to the Right-Angle H K D, you will have 108 Degrees 26 Minutes, for the Angle of the Flank H K F.

For to find the Line Racing, A F or B K, you muſt firſt find the Line D K, which this Author calls the Complement, by the following Proportion.

As Radius	90 : 00	10.000000
Is to the Hypothenuſe D H	39.8 Fa.	1.599883
So is (*s*) of the Angle at the Epaul A H K	126:52	9.903108
To the Complem. DK	31.8 Fa.	1.502991

Which being found to be 31 Fathoms, and near 5 Feet, if it be added to the Tenail AD, before found to be 94 Fathoms, 5 Feet, the Sum will give 126 Fathoms, for the Line Raceing A F.

By the means of the Complement DK, found to be 38.8 Fathoms, you may find the Courtain K F, by making the Triangle K D F in the following Proportion.

As (s) of the Diminiſhed Angle DKF——	-18 : 26—	0.500036
Is to the Complement D F——	-31.8 Fa.	1.502427
So is (s) of double the Angle DKF	-36 : 52—	9.778119
To the Courtain K F——	60.3 Fa.—	1.780582

Which being found to be 60 Fathoms, and near 2 Feet, it will ſerve to find the prolonged Courtain F S, by making the Oblique Triangle A S F, in the following Proportion.

As (*s*) of the Demi-Angle of the Polygon A S F	60 : 00—0.062469
Is to the Line Raceing A F	126 Fa.—2.100371
So is (*s*) of the Demi-flanked Angle S A F	41 : 34—9.821835
To the prolonged Courtain SF	96.5 Fa.—1.984675

Which being found to be 96 Fathoms, 3 Feet, if you ſubtract therefrom the Courtain K F, before found to be 60 Fathoms, and 2 Feet, you will have 36 Fathoms, and 1 Foot for the Demi-Gorge S K; the which being added to the ſame Courtain prolonged S F, or 96 Fathoms, and 3 Feet, you will have 132 Fathoms, and 4 Feet, for the Side of the Interior Polygon S Y.

Laſtly, one may find the Capital A S, in making in the ſame Oblique Triangle A S F, the following Proportion.

As

As (s) of the Demi-Angle of the Polygon ASF——	60 : 00	0.062469
Is to the Line Raceing AF——	126 Fa.	2.100371
So is (s) of the Diminished Angle AF S	18 : 26	9.499964
To the Capital AS	46 Fa.	1.662804

☞ Here Note, *That I have called* **A S F**, *the Demi-Angle of the Polygon, it being its Complement to a Semi-circle, or* 180 *Degrees, which is* 120 *Degrees; therefore if one ſearches in the Table for the Angle* **A S F**, *he muſt find its Complement to a Semi-circle, or* 180, *which is* 60 *Degrees, the ſame as the Demi-Angle of the Polygon* **V S Y**; *the like you will find in all other Polygons.*

CHAP.

CHAP. XI.

The Idea and Conſtruction of Monſieur Vauban.

THIS *Author*'s Method is not much different from that of Count *Pagan*'s, as one may ſee by his Works; eſpecially by his new Methods of Towers and Baſtions at *Landau*, and now at *Briſack.* It is true, that his principal Deſign has been to reform the Errors of the greateſt part of his Predeceſſors, and of his Contemporaries, touching the Gorges and the Flanks of the Baſtion, which he found too ſtrait for there to make Retrenchments, and to put Batteries ſufficient for to reſiſt thoſe of the Enemies; and ſeeing that the Muſkeeters were ill placed amongſt the Smoak of the Batteries, he has rather choſe to place them in the Bottom of the Ditch, covered by a good Parapet made in Tenail,

nail, then to place them in the Flanks, finding again this Advantage, that by drawing them near as (much as he would) the Point of the oppoſite Baſtion, he could by that means, remove the Baſtion from thence, the Port of a Musket, and in the Circumference of a Town, diminiſh the Number of the Baſtions, and conſequently the Expence.

Laſtly, He having perceived, that it was no longer the Cuſtom to make the Breach in the Baſtion with the Cannon, where it requires much time to make a Paſſage reaſonably large; and that in 24 Hours ordinarily the Mine was near ready to be ſprung, he is little ſolicitous for the Flank-Angle to be Acute or Obtuſe, receiving them both indifferently, provided they have a ſufficient Solidity: This is his Idea which he has put in practice in more than 100 Places, which he has fortified, having been the moſt followed, and moſt eſteemed Ingineer in *Europe*.

Having deſcribed a Circle, and therein made a Polygon of what number of Sides you pleaſe, which ſuppoſe as in *Fig.* 10. an Hexagon: Divide the Exterior Side of the Polygon A B, into 2 equal parts in the Point C, and with a Ruler laid on the Point C, and the Center O, draw the

Per-

Perpendicular C D, as in the Fortification of Count *Pagan*, equal to the eighth part of the Side of the Exterior Polygon A B, for the Square, and a ſeventh for the Pentagon, and to a ſixth for the Hexagon, as here, and the ſame for all other Polygons, draw by the Point D, and Extremities of the Line A and B, the Lines of Defence A D H, and B D G, which will terminate in the Points G and H, in the following manner.

Divide the Exterior ſide A B, into 7 equal parts, and give two thereof to the Faces A E and B F; and draw the Lines E H and F G, each equal to the diſtance E F, for to have the Courtain G H, and the Flanks E G and F H; and if one doth the ſame for all other Parts, one ſhall have the firſt Draught of the Courtains and Baſtions, to which muſt be added within a Rampart of 12 Fathoms thick, with a Parapet of 3 Fathoms thick, with a Ditch towards the flanked Angle, from 16 to 18 Fathoms wide, and 20 towards the Epaul.

For to make the Cazemats and Orillons, make the Line E I and F I, equal to one third of the Flank E G and F H; and draw by the Point I, from the Points of the oppoſite Baſtions A and B, the Line

A O, and B O; make the Reverſe of the Orillons I O, 5 Fathoms; place the ſame diſtance alſo on the prolonged Line of Defence, for the Inforcement of the Cazemat G P and H P; after which, the Circular Flank O P, is thus deſcribed wih the diſtance O P; from O and P, ſweep the two Arches interſecting each other in the Point 2, and from 2, with the diſtance 2 O, or 2 P, ſweep the Arch O P, for the Circular Flank: For the Orillons, they are deſcribed by making on the Line E I, an Arch of a Circle, the Diameter of which, will be a little leſs than the Line E I, in ſuch ſort, that the Convexity doth not exceed, or go beyond the Line of Defence, and is thus formed; Divide the Line E I, into two equal parts, from the middle of which, and alſo from E, draw two Perpendiculars, which will Interſect each other in the Point 3; then from 3, with the Diſtance 3 E, deſcribe the Orillon.

This *Author* adds in the Ditch, a Tenail or Tenail reinforc'd, as in *Fig.* 11. which he makes thus: Set off on the Line of Defence, A H and B G, from E to K, and from F to K, 6 or 7 Fathoms; and draw from the Point K, the Line K 1, parallel to the Flanks F H and E G, for there to terminate Tenails of the Faces; the which, as KQ, is half of the Line IK, and the Flanks QR, are drawn perpendicular to the Lines of Defence within, which Work is made a Rampart, which has towards the Courtain but 5 Fathoms broad, and 7 Fathoms towards the Flanks and Faces: As for the Parapet, it muſt not be leſs than 3 Fathom. As this Work ſeems to me to be made for no other end, than for to ſecure the Paſſage of the Ditch, I think that a ſingle Tenail may be ſufficient; as in *Fig.* 12. is expreſſed by ABC.

Furthermore, for the better clearing the Ditch, and ſecuring its Paſſage, this *Author* adds in the Ditch, over againſt the Middle of the Tenail, a *Caponier*, or a double Covert-way, with a Parapet raiſed above the Level of the Ditch 3 Feet, it is nigh 12 Feet thick, perpendicular to the Courtain, Paliſado'd on every part; this Work is ſo much the better, in that it commands, and is not commanded; and it ſerves for a Way for the Musketeers to gain the Out-works, thus; for the Defence of the Ditch, he has 4 Flanks, that of the Place, that of the Orillon, and thoſe of the Tenail and *Caponier*.

To deſcribe the Ravelins, which now are generally called Demi-Lunes before the Courtain, which is placed at the re-entring Angle of the Counterſcarp: From the Angles of the Epaul F and E, *Fig.* 11. with the Overture of 70 Fathoms, the Exterior Side being 200 (which 70 is a little more than the third part of the Exterior Side of the Polygon) deſcribe two Arches Interſecting each other in the Point S, which ſhall give the Point of the Ravelin, the Faces of which are drawn to the Angles of the Epaul E and F. Here obſerve, That the Capital of the Ravelin C S, is always equal to half the Courtain, with the Inforcement of the Cazemat, as T P, or otherwiſe you may make the Crpital CS, 40 Fathoms for the Square, and 45 for all other Polygons. This Ravelin ſhall have a Rampart of 10 Fathoms thick, and a Parapet, the ſame with that of the Place, and a Ditch of 12 Fathoms wide; and for to hinder the Paſſage of the Ditch, you muſt there make a place of Arms perpendicular to the Face of the Ravelin, and covered with a Parapet of 3 Feet above the Level of the Ditch.

You muſt alſo make againſt the ſame Ravelin a Retrenched *Corps de Garde*; that

is

is to ſay, a *Reduit* or Redoubt, in the Walls of which, are made Battlements or † *Murtiers* for to ſhoot at, and to repulſe the Enemy with the Muskets, and for to retire to, when the Beſieged is ſo preſs'd, that they can no longer ſuſtain the Aſſault: This ſame Ravelin is ſometimes cover'd with a ſort of Counter-guard or Grand Lunette, which are made by placing from the Brink of the Ditch of the Ravelin, from 12 to 15 Fathoms, from *a* to *b*, and from *d* to *g*, and prolonging the Face of the Ravelin, place from 25 to 30 Fathoms, from *e* to *f*, and from *k* to *l*, its Ditch muſt be like that of the Ravelin, in which, and in the Terre-plain of the Ravelin, as alſo in its Ramparts, when it has any, is made a Traverſe or Parapet of 5 Feet, or 5 Feet and a half high, leaving on the ſide of theſe Traverſes, a ſpace of 2 or 3 Feet, for a Rank of Soldiers.

For the better covering of the Ravelins, there is added on the re-entring Angle of the Counterſcarp, a little Ravelin or *Lunette*, which draws its Defence from the two great Lunetts, having a Ditch of 3 Fathoms wide, and as deep as that of the Ravelin, with a Parapet without any Rampart.

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† Murtiers *are ſmall ſlits or holes, to ſhoot through with Muskets.*

This *Author* makes his Covert-way 5 Fathoms broad, with a Glacis of 36 Fathoms.

The double Lines, which are added to the Glacis of the Covert-way over againſt the flanked Angles of the great Counter-guards or Lunetts, repreſent a Cut of 10 Feet wide, which is made in the Glacis, which are called Sallies, becauſe they go out of the Covert-way through them, to make Sallies, and receive Succours in thereat; theſe Sallies or Ways are ſhut with Barriers of Oak.

As for the ſingle Tenail, it conſiſts of no other than a re-entering Angle, as ABC, in that part of *Fig*, 12. mark'd (1); to make the ſame, is no other than following the Line of Defence, leaving from the Points of the Orillons 6 or 7 Fathoms, behind which you muſt draw two Lines parallel thereto: The firſt, of the Diſtance of 13 or 14 Feet, which ſhall repreſent the thickneſs of a Parapet; the ſecond, of 4 or 5 Fathoms, which ſhall ſhew the thickneſs of the Terraſs. It is behind this Parapet, where this *Author*

places

places his Muſketeers for to hinder, as I ſaid before in the Conſtruction of the double Tenail, the Paſſage of the Ditch.

To make the Hornwork.

From the Point of the Ravelin, in that part of *Fig.* 12. mark'd (2) from the Point of the Ravelin E, with 88 Fathoms, ſweep the Arch G F H, and place 60 Fathoms from F to G and H, and draw the Right-Line G H, which divide into two equal parts in the Point I, and draw the Perpendicular I K, of 20 Fathoms, drawing by K the Lines of Defence G L and H M of a convenient length, and make the Faces G N and H O, of 35 Fathoms; then if you make the Lines N L and O M, equal to the Diſtance N O, you will have the two Flanks N M and O L, and the Courtain M L, which is finiſhed by drawing the Wings H P and G Q, to the Angle of the Epaul of the next Baſtion; the Ditch of this Work is 12 Fathoms broad, the Parapet is 3, and the Terraſs compriſing the Parapet 8 Fathoms, the largeneſs of the Orillons is half of the Flanks of the ſame Work.

For to make the Counter-guard before the Ravelin,

Set off from the ſide of the Ditch of the Ravelin (in that part of *Fig.* 12. mark'd 3.) from R and S 15 Fathoms, which will give R V and S T; from the Points T and V, draw the Faces T W and V W, parallel to the Ditch of the ſaid Ravelin, and you will have the Counter-guard, to which give a Parapet of 3 Fathoms, and a Terraſs (compriſing the Parapet) of 8 Fathoms, the Ditch muſt be 12 Fathoms wide.

The Counter-guard before the Baſtions, are made in every reſpect after the ſame manner.

For to make the Crown-work before the Ravelin.

If you will make the Ravelin a Half-Moon, as you ſee done in that part of *Fig.* 11. mark'd (4) it is nothing elſe but to retrench the two Demi-Gorges thereof, C D and E F, each 5 Fathoms; then draw C O and E Q perpendicularly; which being done on A, the Point of the Ravelin, with 100 Fathoms deſcribe the Arch G B H, and place the ſame diſtance from B to H and G, and draw the two ſtrait Lines B G and B H, afterwards divide theſe two Lines, each into two equal parts, as in the Point I, and make the perpendicular I K, 16 Fathoms; then draw draw by the Point K, the Lines of Defence G M and B L, of a convenient length, and make each Face B P and G R, 31 Fathoms, and make R M and P L, equal to the diſtance R P; then draw the Lines P M, R L, and L M, and you will have the Flanks and the Courtains drawn, do the ſame with the ſide B H: After which, if you draw the Wings G T and H S, to the Angle of the Epaul of the two next Baſtions, you will have the Crown finiſhed, which muſt be fortified within with a Parapet of 3 Fathoms, and with a Terraſs of 8 Fathoms, compriſing the Parapet, its Ditch muſt be of 12 Fathoms broad: The Orillons are half of the Flanks.

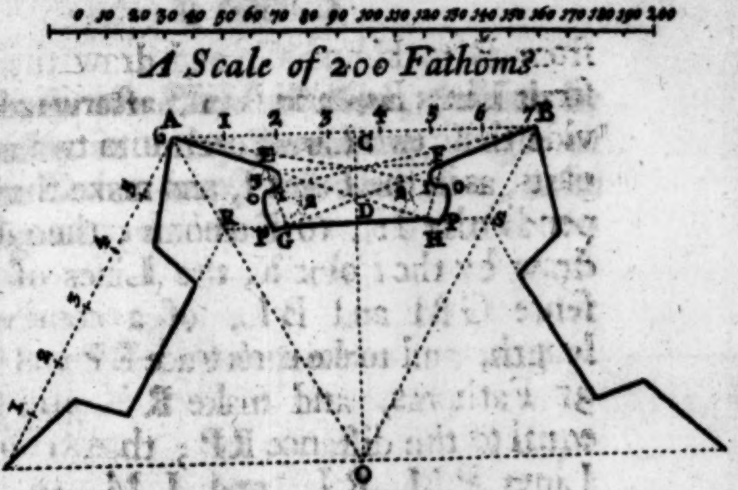
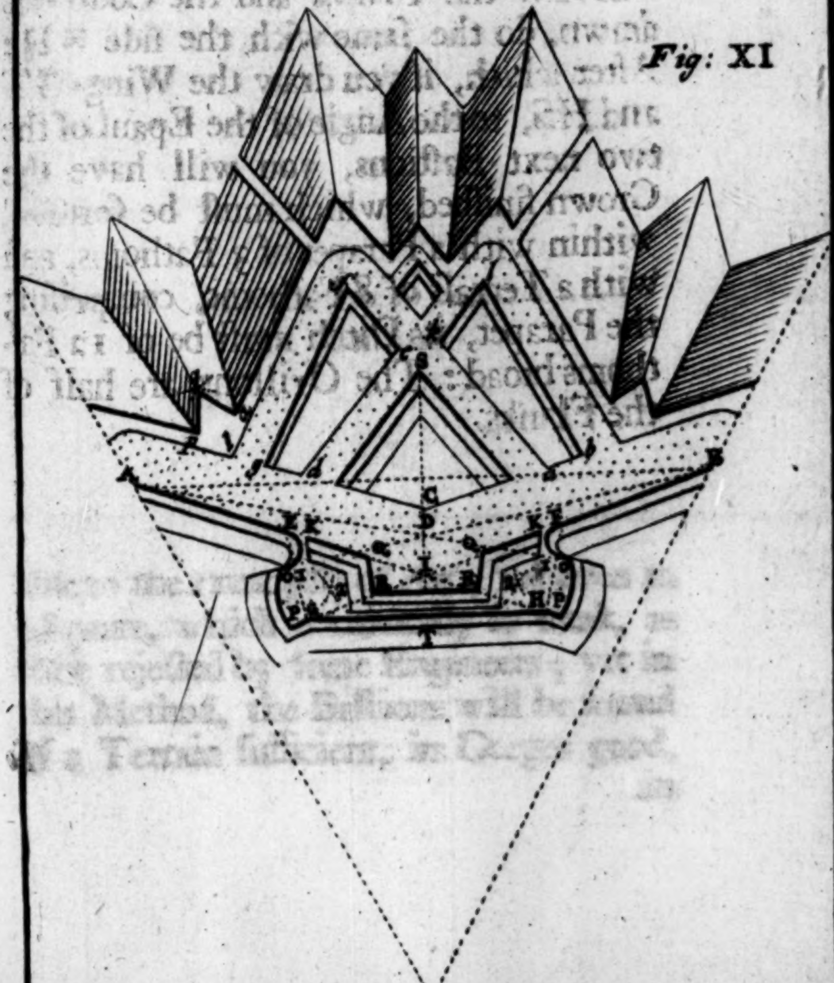

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
A Scale of 200 Fathoms
A
1
2
3
4
5
6
7
B
C
E
F
D
R
S
P
G
H
O

Fig: XI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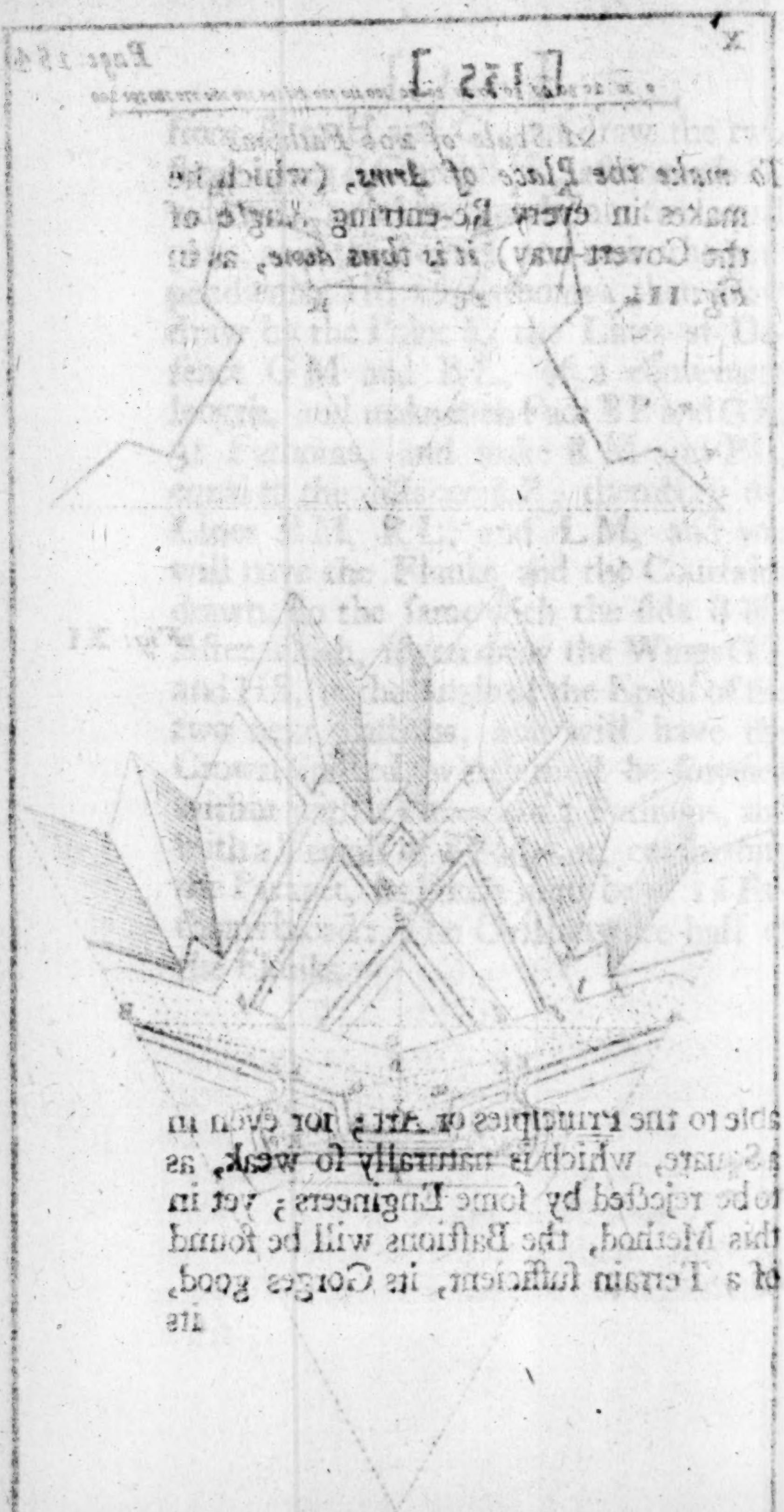
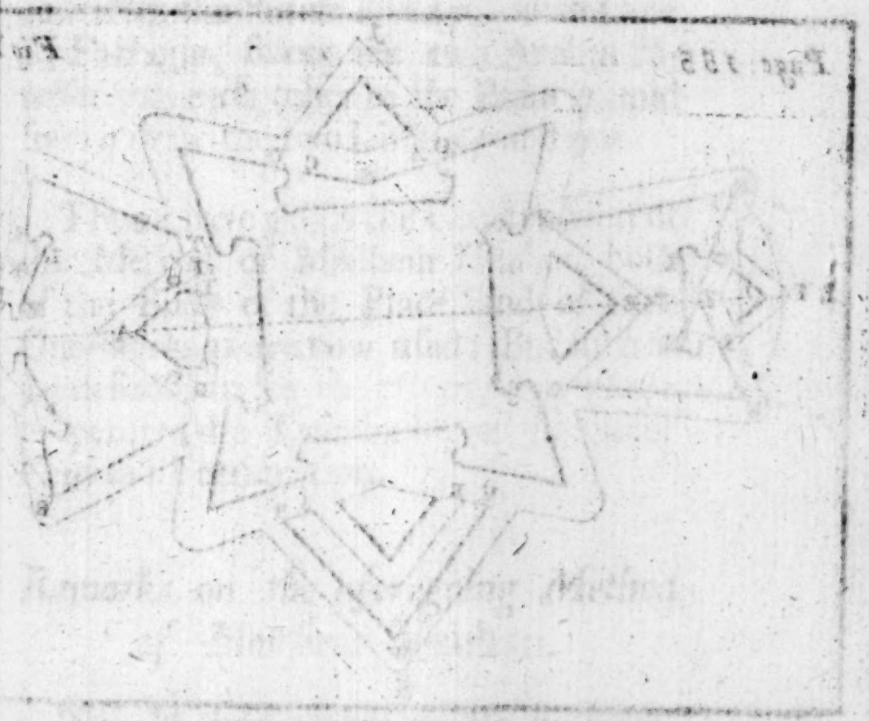
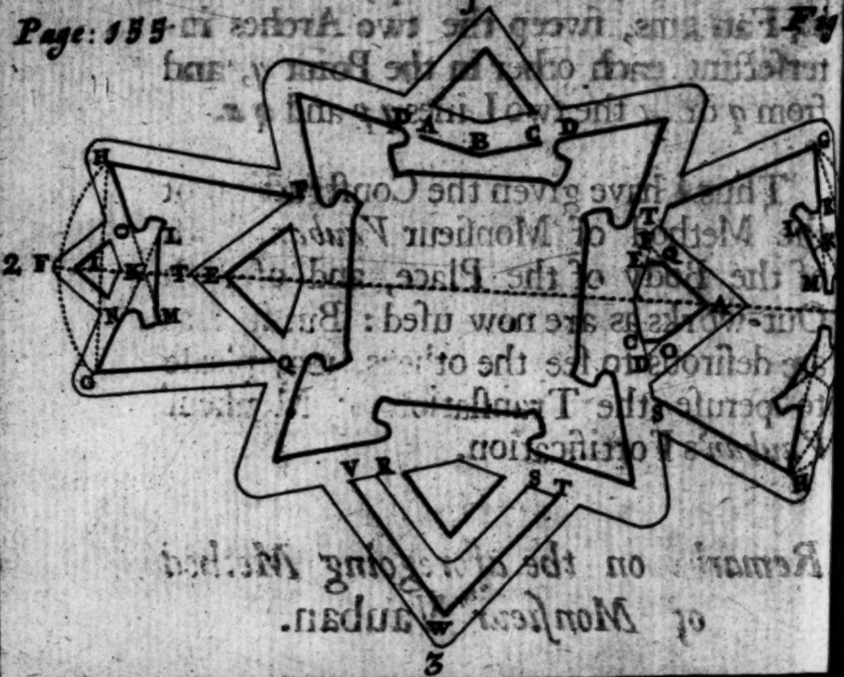


To make the Place of Arms, (which he makes in every Re-entring Angle of the Covert-way) *it is thus done*, as in *Fig.* 11.



able to the Principles of Art; for even in a Square, which is naturally ſo weak, as to be rejected by ſome Engineers; yet in this Method, the Baſtions will be found of a Terrain ſufficient, its Gorges good, *Page: 155*



To make the Place of Arms, (which he makes in every Re-entring Angle of the Covert-way) *it is thus done*, as in *Fig.* 11.

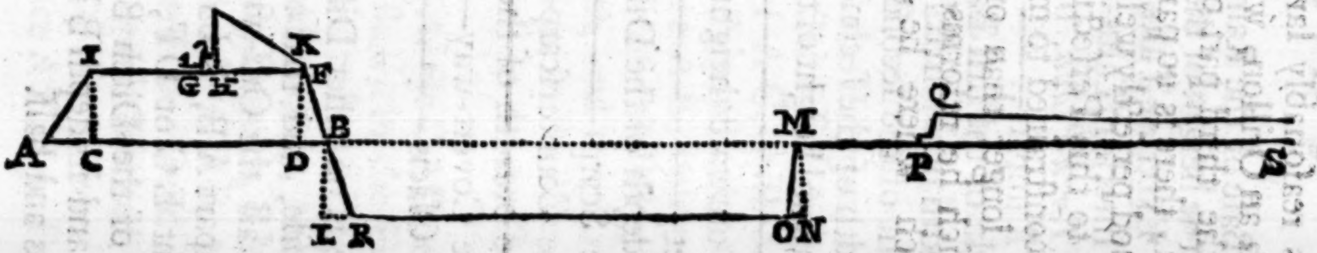
Set off 10 Fathoms from *l* to *a* and *p*, and from the Points *a* and *p*, with 12 or 13 Fathoms, ſweep the two Arches interſecting each other in the Point *q*, and from *q* draw the two Lines *q p* and *q a*.

Thus I have given the Conſtruction of the Method of Monſieur *Vauban*, both of the Body of the Place, and of ſuch Out-works as are now uſed: But ſuch as are deſirous to ſee the others, may pleaſe to peruſe the Tranſlation of Monſieur *Vauban*'s Fortification.

Remarks on the aforegoing Method of Monſieur Vauban.

This Method is very exactly conformable to the Principles of Art; for even in a Square, which is naturally ſo weak, as to be rejected by ſome Engineers; yet in this Method, the Baſtions will be found of a Terrain ſufficient, its Gorges good, its Flanks reaſonably large, cover'd always with an Orillon, whoſe largeneſs is equal to the third part of the length of the Flank, there is no part that is not in this Method perfectly well defended; but to arrive to this Perfection, this *Author* has been conſtrained to make his Lines of Defence, longer than ordinary Musket-ſhot, which he reforms by a Tenail in the Ditch where he places his Muſketeers.

The Profile of Monſieur Vauban's *Method.*



	Fa.	Fe.
A B, the Baſe of the Rampart	11	—
CE, DF, the height of the Rampart	3	—
BD, the Exterior Talus	1	—
AC, the Interior Talus	1	4
E G, the *Terra-Plana*, or Walk on the Rampart	4	—
The height of the firſt Banquet	—	1½
The breadth of the firſt Banquet	—	1½
The height of the ſecond Banquet	—	1½
The breadth of the ſecond Banquet	—	2
H I, the inward height of the Parapet	—	8
G H	—	4
F K, the outward height of the Parapet	—	2
L B, the depth of the Ditch	3	—
L R, the Scarp	—	4
O N, the Counterſcarp	—	2
B M, the breadth of the Ditch	20	—
M P, the Covert-way	5	—
P S, the Glacis	36	—

There is no other Difference between this Profile, and that of the Out-works, only in all the Out-works, the Baſe of the Rampart A B, is but 8 Fathoms, and its height E C or D F, but 14 Feet, the breadth of the Ditch B M, but 12 Fathoms, and its depth B L or M N, but 2 Fathoms and half.

To

To Calculate the Angles and Lines according to the aforeſaid Method of Monſieur Vauban.

THE Line A B in *Fig.* 10. being the ſide of an Hexagon, the Angle of the Center A O B, will be 60 Degrees, and the Angle of the Polygon, 120 Degrees. If the Exterior ſide A B, be 120 Fathoms, the half A C, will be 90 Fathoms, and the Perpendicular C D, 30 Fathoms, the Face A E, being two ſevenths of the Side of the Polygon A B, will be 51 Fathoms, and near 2 Feet, but for to avoid Fractions in Practice, it is ordinarily ſuppoſed 50, as we ſhall here do.

The diminiſhed Angle C A D or C B D, will be found, as ſhewn in the Fortification of Count *Pagan*, to be 18 Degrees, 26 Minutes; and conſequently, the flanked Angle at A or B, 83 Degrees, 8 Minutes, and the flanking Angle A D B, 143° 08′ the Line A D, will be found alſo, as ſhewed in Count *Pagan*'s Method, 94 Fathoms, and near 5 Feet; from which, ſubtracting the Face A E, or 50 Fathoms, there will remain 44 Fathoms, 5 Feet, for the Line E D or F D.

And in the Oblique Triangle E D F, may be found the Line E F, by the following Proportions.

As (s) of the Angle E F D——} 18 : 26——0.500036
Is to the oppoſite ſide D E——} 44.8 Fa.--1.651278
So is the Angle EDF 143 : 8——9.778119
To the oppoſite ſide EF-85 Fa.--1.929433

Thus the Line F F or F H, which are equal, being found near 85 Fathoms; to which being added 50 Fathoms for the Face A E, one ſhall have 135 Fathoms for the Line of Defence A H; from which 85 Fathoms ſubtract D E, or 44 Fathoms, 5 Feet, one ſhall have 40 Fathoms, 1 Foot, for the Complement D H or D G.

And in the Iſoſcele Triangle G D H, one may find the Courtain G H, by the following Proportion.

As

As (*s*) of the Angle D G H——	18 : 26—0.500636
Is to the oppoſite ſide D H——	40.1 Fa.—1.603144
So is (*s*) of the Angle G D H——	143 : 8—9.778119
To the oppoſite ſide ſide G H——	76 Fa.—1.881299

Which one might have alſo found without knowing the Angles, in comparing together the two Iſoſceles-Triangles alike G D H, and E D F.

Since the Triangle E F G is an Iſoſceles-Triangle, if from 180 Degrees, one ſubtracts the Angle E F G, which is equal to the diminiſhed Angle, which has been found to be 18 Degrees, 26 Minutes, there will remain 161 Degrees, 34 Minutes; the half of which will give 80 Degrees, 47 Minutes for the Angle at the Baſe, E G F; to which, if one adds the diminiſhed Angle G H E, or 18 Degrees, 26 Minutes, one ſhall have 99 Degrees, 13 Minutes, for the Angle of the Flank E G H or F G H; to which again adding the diminiſhed Angle GHE, 18 Degrees 26 Minutes, one ſhall have 117 Degrees 39 Minutes, for the Angle of the Epaul AEG.

For to find the Flank EG, in the Triangle EDG, one may make the following Proportion.

As (*s*) of the Angle EGD ——	80 : 47 —— 0.005643
Is to the oppoſite ſide ED -- ——	44.8 Fa. -- 1.651273
So is (*s*) of the Angle EDG -- ——	36 : 52 -- 9.778119
To the oppoſite ſide EG ——	27 Fa. -- 1.435035

Having found the Flank EG, to be near 27 Fathoms, to find the Demi-Gorge PR or PS, one muſt firſt find the prolonged Courtain PS, by making in the Oblique-Triangle AHR, the following Proportion.

As

As (ſ) of the Angle ARH——	120 : 00—0.062469
Is to the oppoſite ſide AH——	135 Fa. —2.130334
So is (ſ) of the Angle HAR——	41 : 34—9.821835
To the oppoſite ſide HR——	103.4 Fa.-2.014638

Which being found to be 103 Fathoms and near 3 Feet, ſubtract from thence the Courtain GH, before found to be 76 Fathoms 2 Feet, there will remain 27 Fathoms 1 Foot for the Demi-Gorge RG or HS, the double of which, or 54 Fathoms 2 Feet, being added to the Courtain GH, or 76 Fathoms 2 Feet, it will give 130 Fathoms 4 Feet for the Side of the Interior Polygon RS.

What has been before ſhewn, I think ſufficient to inſtruct any Perſon to calculate the Lines and Angles of any Fortification. Therefore, for brevity ſake, I ſhall only give the Conſtruction of what follows.

The following Tables are moſt exact, having (as my *Author* tells me) been calculated by the *Authors* themſelves, except that of Monſieur *Vauban*, which I collected from the *Engliſh* Tranſlation, not having the Originals by me at preſent.

A Tabl

A Table of the Measures of the Fortification of Count Pagan.

	Square.	Pentagon.	Hexagon.	Heptagon.	Octogon.	Enneagon.	Decagon.	Endecagon.	Dodecagon.
Angle at the Center.	90 D. 0 M.	72	60	51 26	45	40	36	32 44	30
Half Ang. of the Polygon.	45	54	60	64 17	67 30	70	72	73 38	75
Ang. of Flan. and Courtain.	106 42	106 42	106 42	106 42	106 42	106 42	106 42	106 42	106 42
Angle of the Epaul.	123 24	123 24	123 24	123 24	123 24	123 24	123 24	123 24	123 24
The Flanked Angle.	56 36	74 36	86 36	95 10	101 36	106 36	110 36	113 52	116 36
The Flanking Angle.	146 36	146 36	146 36	146 36	146 36	146 36	146 36	146 36	146 36
The Radius.	71 fat. 1 f. 2 I.	101 4 : 1	129 4 : 11	157 1 : 13	184 1 : 11	211 1 : 10	138 1 : 5	265 — : 9	292 — : 2
The Demy-gorge.	20 1 : 4	29 3 : 11	34 4 : 9	38 — : 7	40 2 : 6	42 — : 11	43 3 : —	44 3 : 6	45 2 : 9
Courtain.	60 1 : 5	60 1 : 5	60 1 : 5	60 1 : 5	60 1 : 5	60 1 : 5	60 1 : 5	60 1 : 5	60 1 : 5
The Flank.	20 4 : 5	20 4 : 5	20 4 : 5	20 4 : 5	20 4 : 5	20 4 : 5	20 4 : 5	20 4 : 5	20 4 : 5
The Face.	50 5 : 4	50 5 : 4	50 5 : 4	50 5 : 4	50 5 : 4	50 5 : 4	50 5 : 4	50 5 : 4	50 5 : 4
The Capital.	48 4 : 7	42 3 : 9	39 4 : 11	38 1 : 7	37 1 : 11	36 4 : 2	36 1 : 6	35 5 : 7	35 4 : 2
The Exteriour Side.	169 3 : 10	169 3 : 10	169 3 : 10	169 3 : 10	169 3 : 10	169 3 : 10	169 3 : 10	169 3 : 10	169 3 : 10
The Interiour Side.	100 4 : 1	119 3 : 3	129 4 : 11	136 2 : 6	141 — : 5	144 3 : 3	147 1 : 5	149 2 : 4	151 1 : —

A Table of the Meaſures of the Fortification of Monſieur Vauban.

	Square.	Pentagon.	Hexagon.	Heptagon.	Octagon.	Enneagon.	Decagon.	Endecagon.	Dodecagon.
The Ang. at the Center.	90 D. 0 M.	72	60	51 26	45	40	36	32 44	30
Half Ang. of the Polygon.	45	54	60	64 17	67 30	70	72	73 38	75
Ang. of Fla. and Court.	98 30	101 50	106	102 30	103	106	93	101 30	101 30
The Angle of the Epaul.	112 30	116	121 40	120	121	125	115	125	128
The Flanked Angle.	63	77	87	95	100	100	100	100	100
The Flanking Angle.	67 30	64	58 20	60	59	55	65	55	52
The Great Radius.	127 fa. 2 feet.	153 1 : —	180 — : —	207 3 : 1	235 1 : —	273 1 : —	291 2 : —	319 — : —	347 4 : —
The Exterior Side.	180	180	180	180	180	180	180	180	180
The Perpendicular.	22	25	27	27	28	32	36	37	42
The Face.	55	50	50	50	50	50	52	52	52
Complem. of Line of Def.	33	38 3	38	38	38	38	38	38	38
The Flank.	18 1	22 1	25	24	25 4	29	32	32 2	37
The Line of Defence.	126	131 3	136	135 3	137 3	138	135	135	137
The Courtain.	64 4	73 4	71	72	71 4	70 3	70 3	70	69

The Glacis.	The Place of Arms.	The Covert-way.	The Ditch.	The Second Banquet.	The First Banquet.	Base of the Parapet.	Rampart.
36 fa.	13 fa.	4 fath.	16 or 20 fa.	2 feet.	1⅓ feet.	3 fath.	11

A Table of the Meaſures of the Fortification of Marlois.

	Square.	Pentagon.	Hexagon.	Heptagon.	Octogon.	Enneagon.	Decagon.	Endecagon.	Dodecagon.
The Angle at the Center.	90 D. 0 M.	72	60	51 26	45	40	36	32 44	30
Half the An. of the Polyg.	45	54	60	64 17	67 30	70	72	73 38	75
The Ang. of Fl. & Court.	90	90	90	90	90	90	90	90	90
The Angle of the Epaul.	105	109 30	112 30	114 38	116 15	117 30	118 30	119 19	120
The Flanked Angle.	60	69	75	79 17	82 30	85	87	88 38	90
The Flanking Angle.	150	141	135	130 43	127 30	125	123	121 22	120
The Radius.	77 fat. 1 foot.	96 4 f. 7 I.	117 2 : 9	138 4 : 7	160 3 : —	182 3 : 3	204 5 : —	227 1 : 11	249 5 : 7
The Demi-Gorge.	18 2 : 9	20 5 : 3	22 4 : 4	24 1 : 3	25 2 : 6	26 2 : 7	27 1 : 9	27 5 : 5	28 4 : 1
The Second Flank.	14 1 : 3	22 3 : 2	25 5 : 9	27 4 : 5	28 4 : 6	29 2 : 4	29 4 : 10	30 — : 7	30 1 : 10
The Middle part.	43 3 : 6	26 5 : 8	20 — : 6	16 3 : 2	14 3 : —	13 1 : 4	12 2 : 3	11 4 : 9	11 2 : 4
The Courtain.	72	72	72	72	72	72	72	72	72
The Flank.	15 2 : 11	17 3 : 1	19 — : 5	20 1 : 10	21 2 : —	22 1 : 1	22 5 : 5	23 3 : 2	24 — : 5
The Face.	48	48	48	48	48	48	48	48	48
[illegible]	2 : 10	41 2 : 9	43 1 : 5	44 4 : 7	46 — : 5	47 1 : 2	48 1 : —	48 5 : 10	49 4 : 7

A Table of the Measures of the Fortification of Chevalier Ville.

	Square.	Pentagon.	Hexagon.	Heptagon.	Octagon.	Enneagon.	Decagon.	Endecagon.	Dodecagon.
The Angle at the Center.	90 D. 0 M.	72	60	51 26	45	40	36	32 44	30
Half Ang. of the Polygon.	45	54	60	64 17	67 30	70	72	73 38	75
Ang. of Flan. and Court.	90	90	90	90	90	90	90	90	90
The Ang. of the Epaul.	104 2	104 2	105	109 17	112 30	115	117	118 38	120
The Flanked Angle.	61 56	79 56	90	90	90	90	90	90	90
The Flanking Angle.	151 56	151 56	150	141 26	135	130	126	122 44	120
The Radius.	48 fa. 5 fe. 1 I.	102 — : 6	120 — : —	138 1 : 8	156 4 : 9	175 2 : 7	194 1 : —	212 5 : 10	131 4 : 1
The Demy-Gorge.	20	20	20	20	20	20	20	20	20
The Second Flank.	0	0	5 2 : 2	22 5 : 1	31 4 : 3	37 — : 8	40 4 : 6	43 2 : 3	45 2 :
The Middle part.	80	80	69 1 : 8	34 1 : 11	16 3 : 5	5 4 : 8	1 3 : —	6 4 : 6	10 4 :
The Courtain.	80	80	80	80	80	80	80	80	80
The Flank.	20	20	20	20	20	20	20	20	20
The Face.	54 5 : 10	53 2 : 11	38 3 : 10	37 4 : 6	36 5 : 9	36 1 : 6	35 3 : 10	35 — : 8	34 3 :
The Capital.	47 — : 10	37 4 : 7	34 3 : 10	36 — : 3	36 5 : 9	37 3 : 6	[illegible] — : 3	[illegible] 2 : 3	[illegible] 3 :

CHAP. XII.

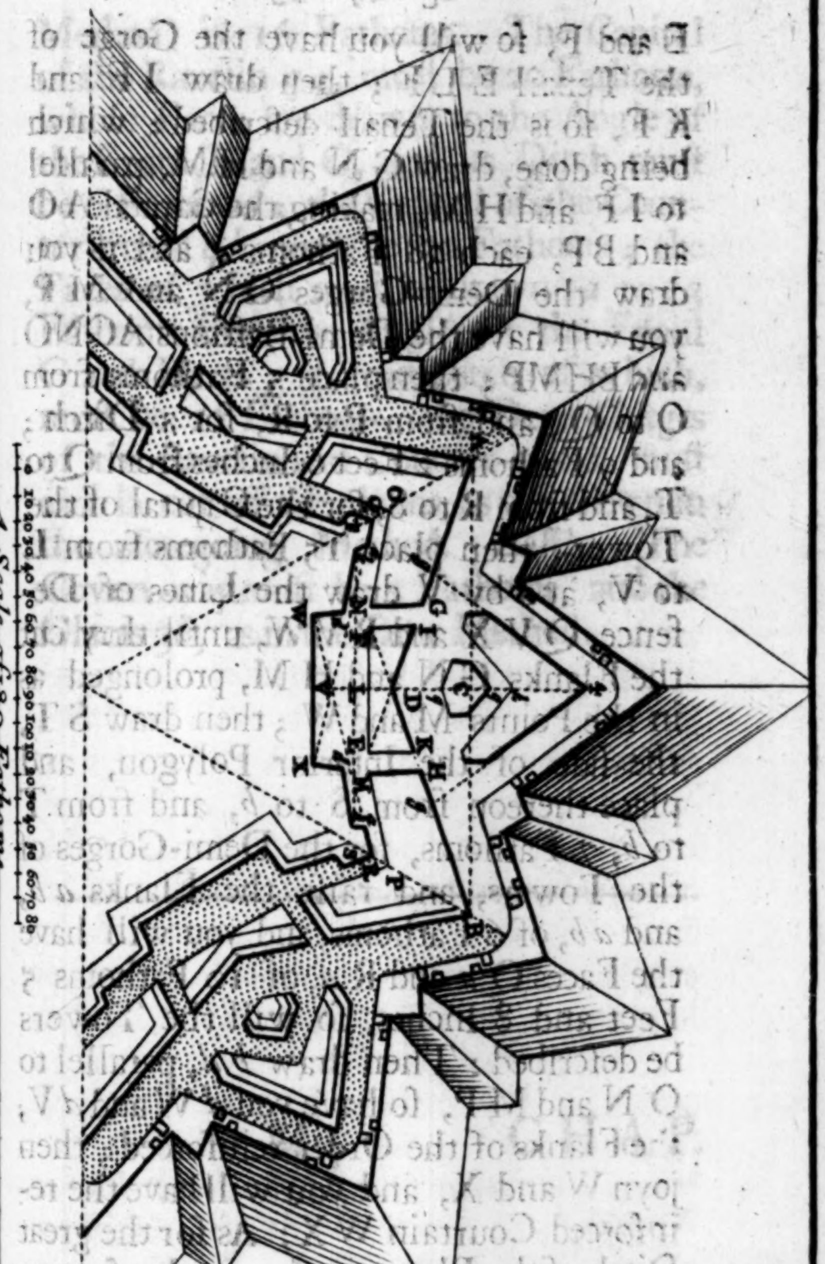
The Conſtruction of the New Method of Monſieur Vauban.

HAVING made a Polygon of what number of Sides you pleaſe, making the ſide of the Exterior Polygon always 180 Fathoms, as here is the ſide of the Hexagon A B, in *Fig.* 13, which divide into two equal parts in the Point C, letting fall the Perpendicular C D of 30 Fathoms, drawing by the Point D, the Lines of Defence A D M and B D N, of any convenient length, and place 60 Fathoms for the Faces of the Baſtions, from A to G, and from B to H, leaving 7 Fathoms for H K and G I, the remainder I D and K D, ſhall be the Faces of the Tenail; then place from D to L, 10 Fathoms, and draw F L E, parallel to A B, and place 24 Fathoms from L, to

E and F, ſo will you have the Gorge of the Tenail E L F ; then draw I F and K F, ſo is the Tenail deſcribed ; which being done, draw G N and H M, parallel to I F and H M, making the Capital A O and B P, each 38 Fathoms ; and if you draw the Demi-Gorges O N and M P, you will have the Demi-Baſtions AGNO and BHMP ; then place 5 Fathoms from O to Q, and from P to R, for a Ditch ; and 9 Fathoms 2 Feet 6 Inches from Q to T, and from R to S, for the Capital of the Tower ; then place 15 Fathoms from L to V, and by V draw the Lines of Defence, Q V X and R V W, until they cut the Flanks G N and H M, prolonged as in the Points M and W ; then draw S T, the ſide of the Interior Polygon, and place thereon from S to *b*, and from T to *b*, 7 Fathoms, for the Demi-Gorges of the Towers, and raiſe the Flanks *a b*, and *a b*, of 6 Fathoms, and you will have the Faces Q *a* and R *a*, of 10 Fathoms 5 Feet and 8 Inches, ſo will the Towers be deſcribed : Then draw *b d*, parallel to O N and M P, ſo have you *d* W and *d* V, the Flanks of the Order reinforced ; then joyn W and X, and you will have the reinforced Courtain W X : As for the great Ditch of the Place, it (as in the former

Me-

Page: 170 *Fig:* XIII



Method) is 16 Fathoms. The Capital of the Ravelin *q q*, muſt be 20 Fathoms, whoſe Faces are drawn to the Angle of the Epaul H and G, and its Ditch muſt be 6 Fathoms; the Capital of the Counter-guard *q k*, muſt be 30 Fathoms; the Faces of which muſt be drawn 12 or 13 Fathoms from the Angles of the Epaul G and H, as *g g*, the Ditch of which, muſt be 12 Fathoms, the Demi-Gorges of the Ravelin and Counter-guard, muſt each be cut off 5 Fathoms, as was ſhewn in the aforegoing Method. Laſtly, The Covert-way muſt be 5 Fathoms, and the Glacis 36, as in the ſame Method.

CHAP. XIII.

The Idea of Monſieur Coehorn.

THIS *Author's* Method of Fortifying, is in a great meaſure to me unknown, I having had the honour to ſee the Plan of his Works, both at *Nimiguen* and *Bergenopzoom*, and his Treatiſe of Fortification; and find that his Works have very little Agreement with what he gives to the Publick in his Fortification; but it appears to me, that his chief deſign is to keep the Enemy as far from the Body of the Place, as poſſibly he can, by a quantity of little Ravelins or Lunettes. At *Bergenopzoom*, I find a Gallery placed on the Counterſcarp to command the Breach from reverſe, and to ſhoot the Enemy behind, which is a Work particular of this *Authors:* As for the reſt, as he was one of the greateſt Men of the Age, both for the offenſive and defenſive part of Fortification; he has, no doubt, followed the moſt perfect Maxims of this Art, he making his Gorges very great, and his Flanks very ſpacious, which he covers with an Orillon, ſtronger and more capable than Monſieur *Vauban*; where he puts part of his Musketeers, without having much regard to the length of the Line of Defence, or to its being ſhortned by the Tenail in the Ditch.

As for the Conſtruction, I wiſh ſome abler Pen would favour the World with it; but if not, if I meet with Incouragement, I hope in a little time to be capable to do it with more certainty, than at preſent; for which Reaſons I have here omitted it.

CHAP.

CHAP. XIV.

The Idea and Conſtruction of Chevalier St. Julien.

THIS *Ingenious Author*, who appears to be a Perſon of great Experience, having obſerved, that beſides the great Expence that many Baſtions in a Fortification occaſion, it requires alſo a greater number of Men to defend them; he has eſtabliſhed a New Method to fortifie the greateſt Places, by which he incompaſſes very near twice the Quantity of Ground with the ſame number of Baſtions as others do, and by that means, both infinitely leſſens the Expence, and requires fewer Men to defend a Place ſo Fortified; it being evident, the more Parts there are to defend, the greater number of Men is required to perform it.

He has likewiſe eſtabliſhed another Method of *Fortification*, for the Middle and Small ſort of Towns; wherein he endeavours to order his Works ſo, that the Beſieged ſhall ſee the Beſiegers, without being ſeen, and that the Beſiegers cannot approach them without being beaten back, not diſcovering the Beſieged any otherwiſe, than by the Shots that are made at them in the Paſſage of the Ditch, or whilſt they pretend an Aſſault, or to lodge themſelves in the Breach.

Which two ſeveral Methods, I ſhall diſtinctly, and as plainly, as is poſſible, give their Conſtruction: And firſt, I ſhall ſhew the Method this *Author* has eſtabliſhed to Fortifie the largeſt Towns.

The Method of St. Julien, *for to fortifie the largeſt Towns.*

He makes the Exterior ſide of the Polygon A B, 240 Fathoms, as in the Hexagon *Fig.* 14. and then divides A B, into two equal parts in the Point C; and draws from the Center V, the Line C V, whih is Perpendicular to A B, placing from C to D, a tenth part of the Side A B, or 24 Fathoms; which being done, draw from A and B by D, the two Lines A D F, and B D E, which are the great Lines of Defence fichant, which are terminated by making the Complements D F and D E, each 70 Fathoms; then draw the Line E F, which ſhall be the great Courtain; then from the middle of the ſaid Courtain, draw the Lines A I and B I, which ſhall be the Lines of Defence raceing; then place from B to H, and from A to G, for the Faces, two tenths of the Line A B, or 48 or 50 Fathoms, 48 Fathoms being two tenths of A B, or 240 Fathoms. Laſtly, Draw the Lines G E and H F, the Flanks; ſo will you have the two Demi-Baſtions finiſhed, A G E and B H F: After the ſame manner draw the reſt.

☞ Here Note, *That the Meaſures that are here given, are general; for the ſame Meaſures are in every reſpect to be obſerved in all Polygons, from the Pentagon, (which is the firſt of this* Author's *Polygons) to the Dodecagon.*

But ſince in this Method the middle of the Courtain is Musket-ſhot from the Points of the Baſtions; ſo that there cannot

not be a ſufficient Defence from the Muſketeers, being that the Baſtions are at too great a diſtance one from another. This *Author*, to ſupply this Defect, has made from the middle of the Courtain, a Work which he calls a *Caponiere*, which traverſes quite the breadth of the Ditch; of which we ſhall give you the Conſtruction after that of the covert Flanks and the Ditch.

Firſt, For the Orillons and covert Flanks; divide the Flanks G E and H F, into 5 equal parts, and give two of theſe parts for the largeneſs of the Orillons, the 3 other parts muſt be for the covert Flanks, which muſt be drawn back 5 Fathoms towards the Baſtion, as in Monſieur *Vauban*'s Method, and is deſcribed as has been there ſhewn.

For the Ditch he places 20 Fathoms, before the Points of each Baſtion, for its breadth, and draws it parallel to the Faces of the Baſtions.

For the *Caponiere*, the Interſection of the two Lines of the Ditch, making the re-entring Angle of the Counterſcarp K; the Point K is the termination of the *Caponiere*, which conſiſts of a Gallery cover'd, of 7 Feet high above the bottom of the Ditch, and 10 Fathoms wide, 4 of which ſhall ſerve for the Cannons; and the other 6, for the two Parapets, on the top of which ſhall be a Gallery uncovered for the Muſketeers, and a Paſſage to the Ravelins.

To make the Ravelins with the Counter-guards; firſt place 45 Fathoms, from K to O, for the Capital of the Ravelin, and place 15 Fathoms, from F and E to P; from which Points P and P, draw the Faces of the Ravelin, the Ditch of which muſt be 10 Fathoms; afterwards place from S to R, 35 Fathoms, for the Capital of the Counter-guard, and draw the Faces thereof parallel to thoſe of the Ravelin; its Ditch muſt he 12 Fathoms.

To make the place of Arms, place from L to M, both ways 15 Fathoms, and make each Face M N, 20 Fathoms, which muſt be covered on each ſide with a Traverſe of 5 Fathoms long, and 3 Fathoms thick, making in the middle of each place of Arms, a Redoubt, there for to place ſome pieces of Cannon and Muſketeers, leaving a ſpace of one Fathom and a half betwixt the Parapet of the Covert-way, and the Redoubt, as Q.

For the Covert-way it muſt be 5 Fathoms, and the Glacis 39 or 40 Fathoms.

The

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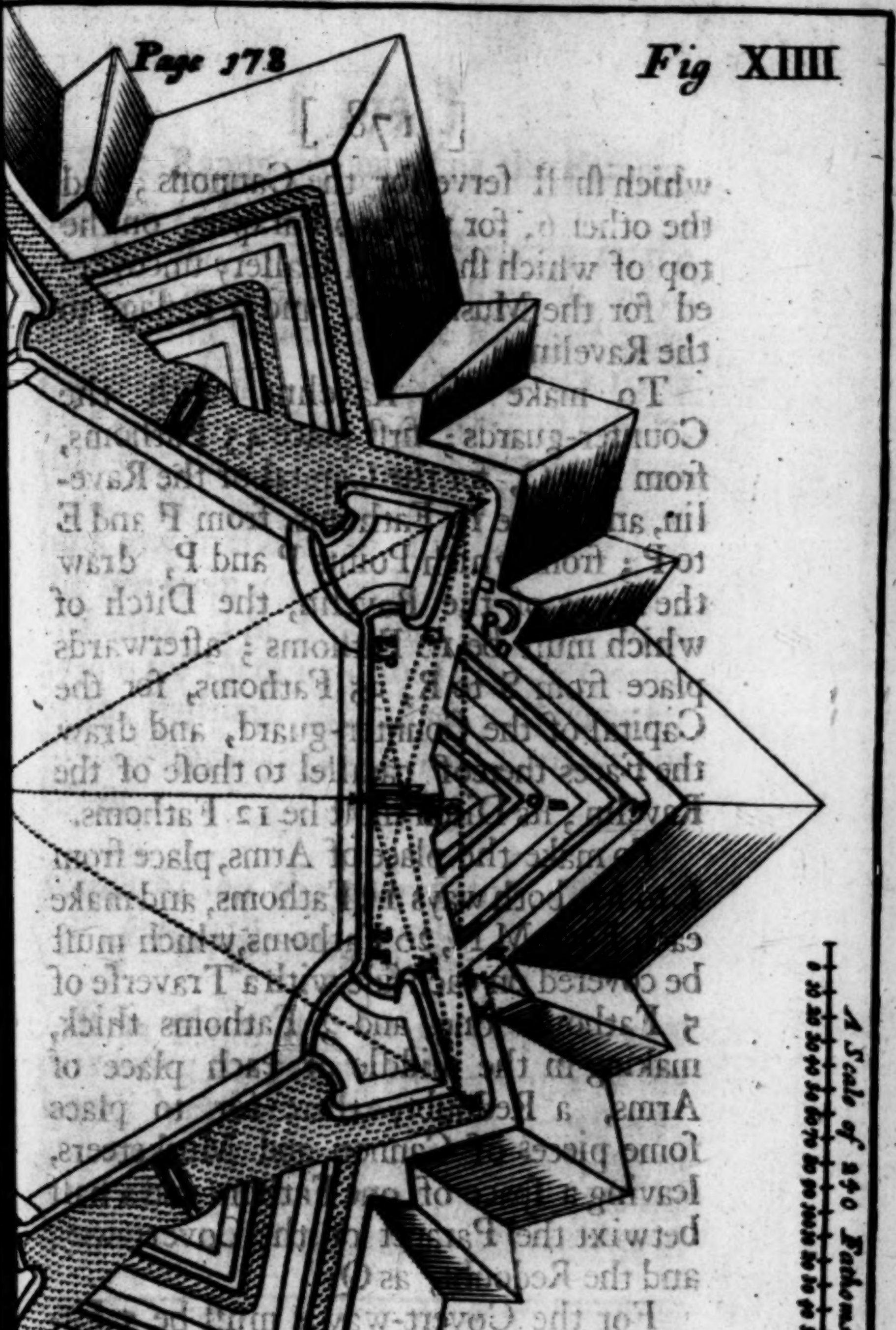
Fig XIIII



The Rampart compriſing the Parapet, muſt be 12 Fathoms thick.

This *Author* makes † Barbettes on the Point of each Baſtion and Ravelin, or otherwiſe he makes on the Rampart quite round the Place, Traverſes at every 10 or 12 Fathoms, which will ſerve to hinder, that the Soldiers be not beaten by * *infilade*. For as much as all his Works being ſunk low in the Earth, may be batter'd on the ſide from a raiſed Battery.

Laſtly, The Cavaliers muſt be made as you ſee them deſcribed on the Gorges of the Baſtions, the which will ſerve for Retrenchments againſt the Efforts of the Enemy.

Remarks on the aforegoing Method of Fortification of St. Julien.

It is plain, that he encompaſſes very near twice the compaſs of Ground, as the largeſt Meaſure of any other Engineer; and by conſequence, in the fortifying of a very large Town, very much leſſens the Expence, and requires the leſs number of

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† *Little Elevations of Earth in form of Traverſes.*

* Infilade, *Is when a place is ſcowered in a direct Line.*

Men to defend it; the Flanks (by reaſon of their diſtance) are not eaſily batter'd by their Cannon; for when the Enemy are lodged on the Covert-way, they are near 200 Fathoms from the Flank of the oppoſite Baſtion; as for the *Caponiere* in the middle of the Courtain, the which can hide 10 pieces of Cannon, and near 100 Musketeers to fire on the Covert-way, defend the Faces of the Baſtions, and Paſſage of the Ditch, and batter from Reverſe in the Breach, and oblige the Enemy for to Intrench themſelves more.

As for the Cavaliers placed in the Gorges of the Baſtions, made in a Circular form Cazemated to the proof of a Bomb, the which Cazemats, and above them, are capaple to contain more than 20 pieces of Cannon, which is of that great Importance, that it ſeems almoſt impoſſible for the Enemy to render themſelves Maſters of the Baſtion.

As for the other Advantages of this Manner of *Fortification*, they will beſt appear in the Profile; which, by reaſon that he therein ſomewhat differs from others, I ſhall proceed to give you.

The

The Profile of the Body of the Place.

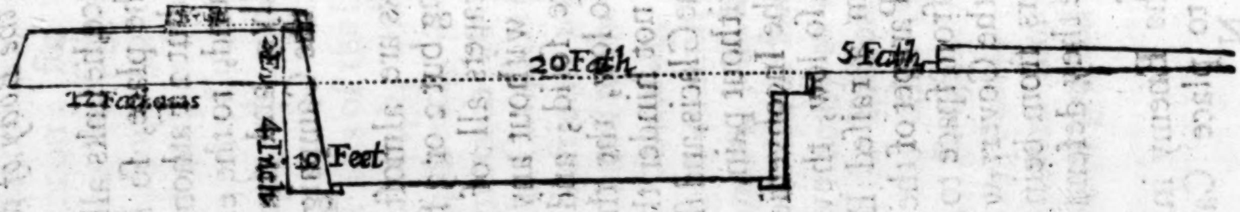
In the firſt place, he ſinks all the Works of the Body of the place, ſo low that his Rampart is raiſed but 2 Fathoms above the Level of the Ground, to the end to ſhoot more Horizontally; and that the Faces almoſt level with the Campaign, may defend themſelves.

The Out-works are almoſt level with thoſe behind, being but 2 or 3 feet lower; he makes his Parapets all of 5 Fathoms thick, and almoſt without any Talus, to render them more ſolid; and being the Works are ſunk ſo low, the thickneſs of the Parapet doth not hinder the Soldiers from defending the Glacis, and ſhooting on the Covert-way without pain.

For to remedy the Inconvenience of the Works being ſunk ſo low, they being eaſily ſcowered from a raiſed Battery, he places behind the Parapet of the Faces and Flanks, Traverſes from ſpace to ſpace, almoſt like them in the Covert-way, which hinders the Soldiers from being battered in the Flank, while they defend the Front againſt the Enemy.

For to batter the Enemy in Barb, he raiſes from place to place Cavaliers of

The Profile of Chevalier St. Julien's Method.



Earth proper to lodge Cannon, which ſerves moreover to divert the fire of the Enemy, who aee obliged to ſeparate their Batteries, to reſiſt thoſe of the Beſieged.

One thing more is worth taking notice of, That as this *Author*'s Rampart is but low, ſo there is in his Ditch of 20 Fathoms broad, Earth ſufficient not only to fill the Baſtions, but alſo to make the moſt large Glacis.

The Method of St. Julien, *for to Fortifie the Middle and Small Sort of Towns.*

This *Author* in this as well as in his aforegoing Method, obſerving the ſame Meaſure in all Polygons, I ſhall give you (as I have done all along in the reſt) an Example of an Hexagon. See *Fig*. 15.

Firſt, make the ſide of the Exterior Polygon A B, 180 Fathoms; on the middle of which, C, draw the Perpendicular C D, the length of which, muſt be a quarter of the length of A B, or 45 Fathoms; then through the Point D, draw the Lines of Defence A E and B F, of any convenient length; on which place, from A to H, and from B to G, 120 Fathoms, which is the diſtance an ordinary Musket is computed to fling a Ball; place alſo on the ſame Line from A to I, and from B to K, 60 Fathoms, for the Faces A I and B K; place likewiſe from D to L and M, 30 Fathoms, for the Complement of the Line of Defence, and draw the two Lines I L and K M, which ſhall be the Flanks of the Baſtions; parallel to which, draw the Lines G N and H O, and you will have the Flanks of the Tenail, on which muſt be lodged the Musketeers for the Defence of the Ditch; then draw from the Angle of the Epaul, the Lines I P and K Q, in ſuch ſort that the Angles F P I and E Q K, be each 60 Degrees (which is eaſily done with a Protracter and Ruler, or ſuch like Inſtrument:) Then draw parallel to P I and K Q, at 8 Fathoms diſtance, the two Lines R T and V S, to the end to ſeparate each Baſtion into two Bodies by the Ditches K Q S V and P I R T.

The Ditch of the place muſt be 16 Fathoms broad, carried parallel to the Faces B K and A I, which will make the reentring Angle in (z.)

Then to make the Ravelins with Counter-guards, place 70 Fathoms from z to *b*, for the Capital of the Counter-guard; alſo place from the Angles of the Epauls on the Face, *viz.* from K to *y*, and from I to *y*, 20 Fathoms; to which Points *y* and *y*, draw the Faces of the Counter-guard *b v*, both ways; then place alſo from *z* to *d*, 45 Fathoms for the Capital of the Ravelin; alſo place from *d* to *e*, 10 Fathoms for the Ditch of the Ravelin; and draw the two Lines *e l* and *d k*, both ways always parallel to the Faces of the Counter-guard *b y*, ſo have you the firſt Draught of the Ravelin and Counter-guard finiſhed. As for the Covert-way, Place of Arms, and Glacis, they are the very ſame with that of Monſieur *Vauban*.

Remarks on the aforegoing Method of Fortification of St. Julien.

It is certain, that the Perpendicular being the fourth part of the ſide of the Exterior Polygon, the Tenail becomes more enforced, and conſequently the Faces of the Baſtions can defend each other, as is evident, which is the firſt Advantage.

Secondly, It is again evident, that the enforcement of this ſame Tenail, makes the Flanks larger, and they have a fire of

Cannon greater, that the Enemy cannot attack, nevertheleſs but at 16 Fathoms diſtance, which is the breadth of the Ditch of the Place, eſpecially if one makes in each Flank two Places or Batteries, the one behind the other, to wit, the high and the low.

Thirdly, The Flanks of the Tenail are ſo large, that one may lodge there 40 Musketeers, which is more than double the number uſually lodged there.

Fourthly, That in this Method the Fire is almoſt quite direct from all parts, for to defend the others: For inſtance, The Ditch of the Ravelin is defended almoſt in a direct Line, by the Faces of the Tenailon, and the Great Ditch round the Counter-guard, is almoſt defended in a direct Line by the Faces of the Counter-Baſtions, which is a conſiderable Advantage.

Fifthly, The Fire which comes from the Ditch of the Baſtion cut off, from whence is ſeen all the Face of the oppoſite Baſtion, which fire off thoſe Cannon, cannot be hindred by thoſe of the Enemy, it being impoſſible that they can diſcover them when they ſhall be lodged in the Ravelin, becauſe the Batteries are between the two Bodies, and raiſed but a little

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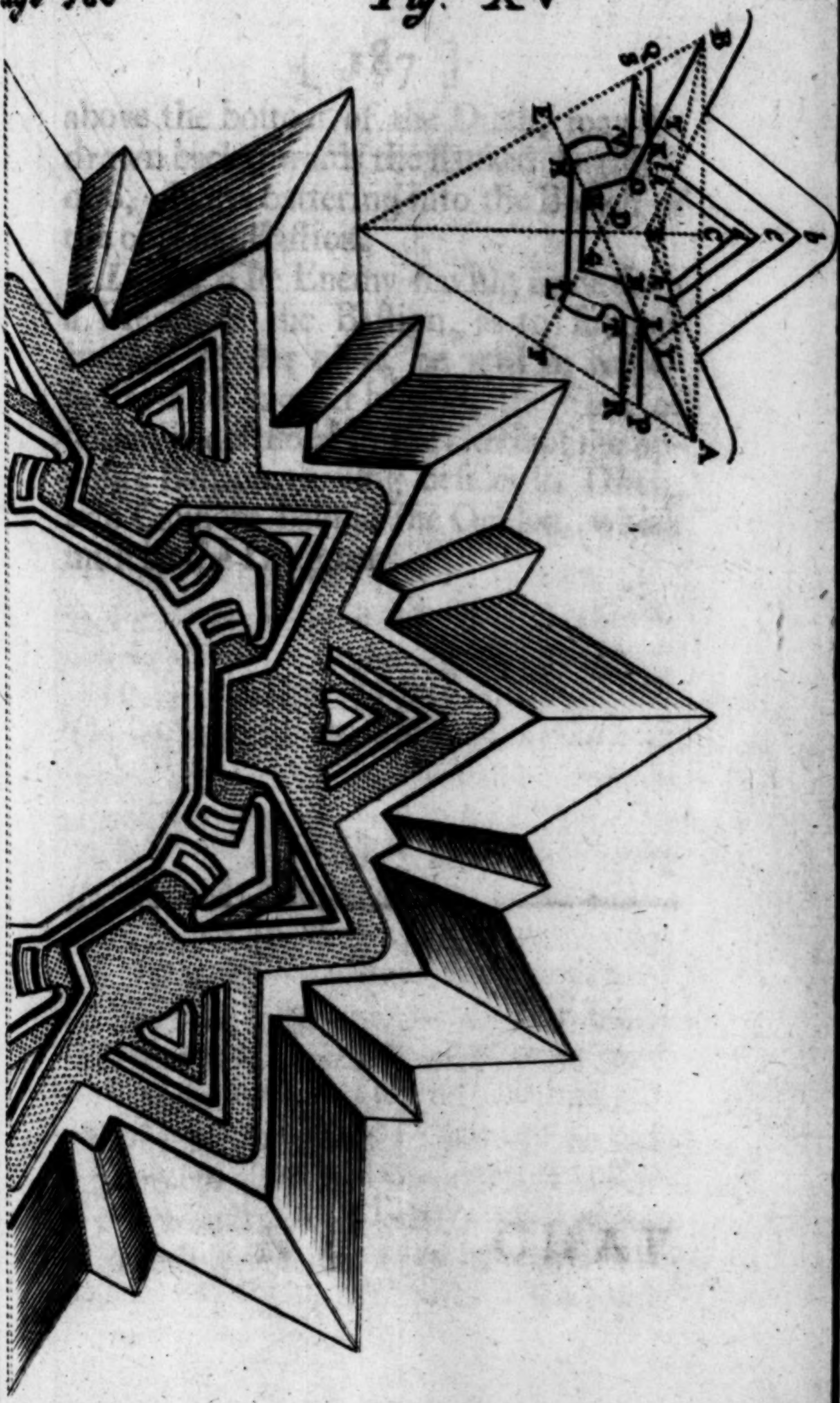
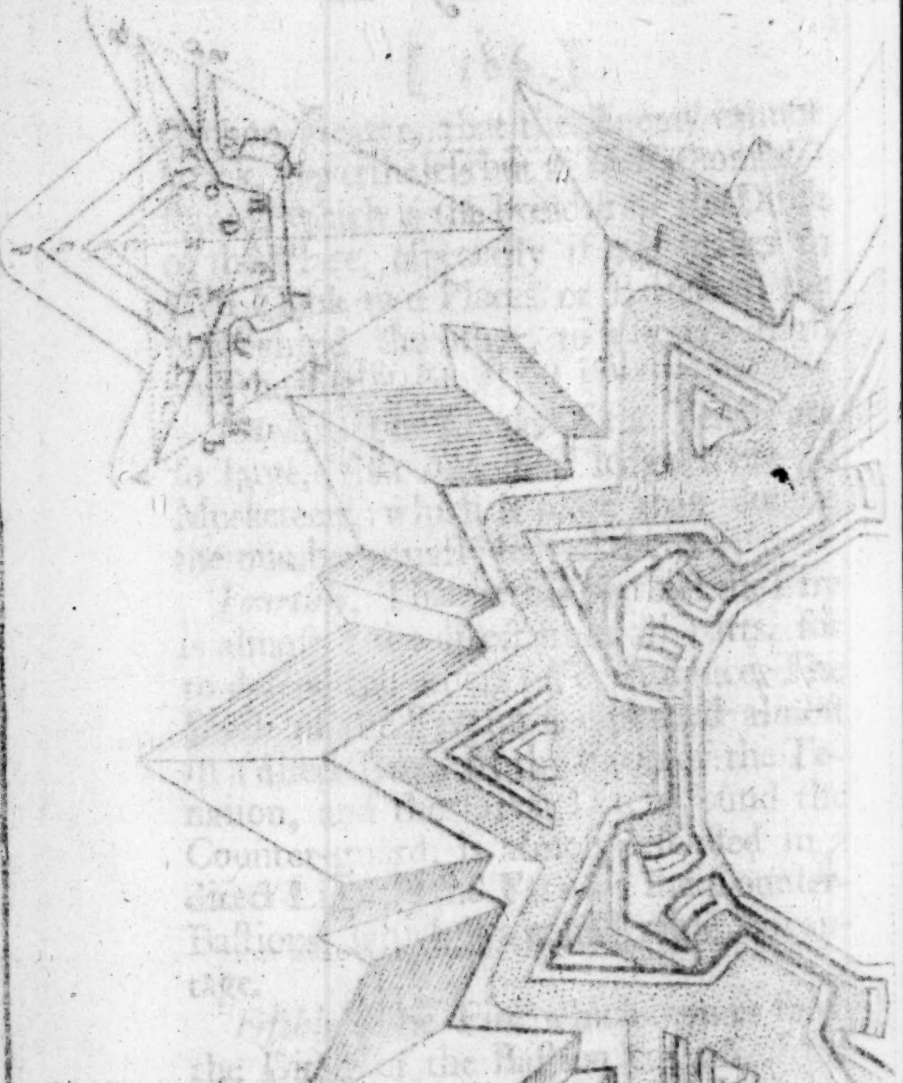
Fig. XV





above the bottom of the Ditch, may be drawn back towards the flanked Angles R or S, always battering into the Breach of the oppoſite Baſtion.

Laſtly, The Enemy having made ſuch a Breach in the Baſtion, as to ſuppoſe himſelf Maſter of it, he will be ſurpriſed to find another behind, the Face of which is defended by the Ditch of the oppoſite Baſtion, having beſides its Ditch, two Cannons behind the Orillon, which muſt be the Lodgment.

CHAP. XV.

The Method to fortifie Places Irregular.

I Underſtand by Places Irregular, thoſe whoſe Sides and Angles are unequal, ſuch as the following Figure, which conſiſts of ſeveral re-entring and unequal Angles, of which ſome are too acute to be fortified as they ought, and the greateſt part of the Sides are alſo unequal; ſome of which are too long, others too ſhort to place Baſtions on the Angles.

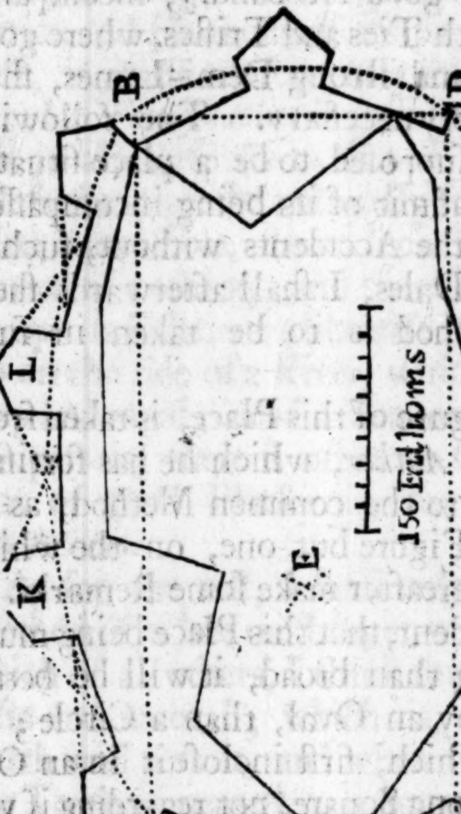
To remedy ſuch Faults, ſeveral *Authors* have been put to abundance of trouble to give Rules capable to reform them, as one may ſee in the greateſt part of Modern, as well as Ancient Authors; and the Figures that they have invented for that end, ſeem to me to be very odd; ſuch as the Quantity of little Salant Angles in form of the Teeth of a Saw, the little Epaulments or Shoulders, the Baſtions *tortus* or bowed in and out, which have neither Gorge nor Flank; the Demi-Baſtions, which have neither Capacity nor Defence; the ſeveral Cuts in Tenail, with which they reform on the Paper the acute Angles, and other the like Inventions; the weakneſs of which ſort of Works will eaſily appear from the Principles which I have before very largely explained, and I muſt confeſs, when I was no Profeſſor of this Art, and contented my ſelf with a more Superficial Knowledge therein, I could not but make ſome Reflections of that kind on a piece of *Fortification*, the Plain of which an Ingenious Engineer of our own Nation, has favoured the Publick with. Therefore I am fully perſwaded, That the beſt Principle in this Art, is to fortifie the moſt Regular as is poſſible, which appears to me to be the Sentiments of Count *Pagan*, Count *Coehorn*, and Monſieur *Vauban*, whatever the ſecond Axiom of *Irregular Fortification* in the Tranſlation of Monſieur *Vaubon*'s Treatiſe of this Art may ſeem to ſpeak to the contrary, *viz.* That the moſt Irregular Forts are the beſt, provided they are not of too eaſie acceſs; it being evident from Reaſon, as well as Art, the more perfect any thing is, the more it is worthy of Eſteem; and that the Perfection of all things conſiſts in the juſt Proportion and Harmony of its parts, which if ſo, it muſt conſequently follow, that *Regular Fortification* is infinitely preferable in all Reſpects to that of *Irregular*, unleſs the place be naturally fortified by being inacceſſible, for on ſuch Sides there is need of nothing; and therefore a good Parapet is ſufficient; likewiſe if it be ſituate on the ſide of a River, which is broad, deep and rapid; or if a Sea or Lake incompaſs it, there is often no other need than of good Platforms, for to hinder the Acceſs.

As for the reſt, I ſhall only give the Method of a late moſt Ingenious Author, which of all others, I think to be the moſt eaſie and natural; which is, when the Earth will permit, and when the form of the Town is neareſt to a Square, incompaſs it with a Circle; but when its form is neareſt to an Oblong, incompaſs it with a ſort of Oval, without regarding if you incompaſs a little more Ground than what the Town ſtands upon; for when it is propoſed to render a Place of good Defence, I am perſwaded that nothing ought to be ſpared that may contribute thereto; and that Ingineer is, no doubt, very much to blame, that to render himſelf agreeable by his good Husbandry, incompaſſes a place with Ties and Trifles, where good Baſtions, and ſtrong Demi-Lunes, ſhall be abſolutely neceſſary. The following Figure is ſuppoſed to be a place ſituated ſo as will admit of its being incompaſſed.

As for the Accidents without, ſuch as Hills and Dales, I ſhall afterwards ſhew what Method is to be taken in ſuch caſes.

The Figure of this Place, is taken from a Modern *Author*, which he has fortified according to the common Method, as in the next Figure but one, on the which we ſhall hereafter make ſome Remarks.

It is evident, that this Place being much more long than broad, it will be better incloſed by an Oval, than a Circle; to perform which, firſt incloſe it in an Oblong, or long Square, not regarding if you therewith cut a little from the place, as you ſee the Oblong A B C doth, which Oblong being made, open your Compaſſes to any convenient diſtance; and from A and C, make the two Arches interſecting each other in the Point E, which will ſerve as a Center for to deſcribe the Arch AFC, do the ſame on the other ſides of the Oblong, and you will have a ſort of Irre-



Irregular Wall, in the which you muſt inſcribe a Polygon, as follows.

Take from the ſame Scale by which the Place was laid down, near 145 or 150 Fathoms, and endeavour with near that diſtance,

ſtance, or ſomewhat more or leſs number of Fathoms, to divide the Oval into equal Parts; this Diviſion of the Oval being done, in equal or near equal parts, draw the ſides of the Polygon from one Diviſion to another.

Then to fortifie this Polygon thus drawn (as *Mallet*) divide each ſide into 5 equal parts, and give one thereof on each ſide for the Demi-Gorge, and on the Extremity of each Demi-Gorge, draw the Lines of the Flanks, ſo that they make an Angle with the Courtain of about 100 Degrees, which is eaſier done with a Demi-circle; then with the ſame Demi-circle examine each Angle of the Polygon, and if you find it near 80 Degrees, give to the length of the Flanks on each ſide that Angle, 17 or 18 Fathoms.

If the Angle of the Polygon is near 108 Degrees, give 20 Fathoms to the Flanks.

If it is near 120 Degrees, give to the Flanks 24 Fathoms.

If it be near 130 Degrees, give to the Flanks 25 Fathoms.

If it be near 135 Degrees, give to the Flanks 26 Fathoms.

If it be near 140 Degrees, give to the Flanks 27 Fathoms.

If it be near 144 Degrees, give to the Flanks 28 Fathoms.

If it be near 147 Degrees, give to the Flanks 29 Fathoms.

Laſtly, If it be 150 Degrees, or much larger, give to each Flank 30 Fathoms.

According to which Rule, having given to all the Flanks their exact length, you muſt draw all the Lines of Defence, from the Angles of the Flanks; or in caſe that the Points of the Baſtions appear to be Obtuſe, then you may reform it by drawing the Lines of Defence from ſome certain meaſure on the Courtains, as you ſee done in the Baſtions K and L, *&c.* ſo will your Baſtions be finiſhed, after which manner you will have Baſtions, which will appear Regular, incloſing a great Terrain capable of Retrenchments, and ſolid in every reſpect.

As for the Rampart, Parapet, Ditch, *&c.* they are the ſame as in *Regular Fortification.*

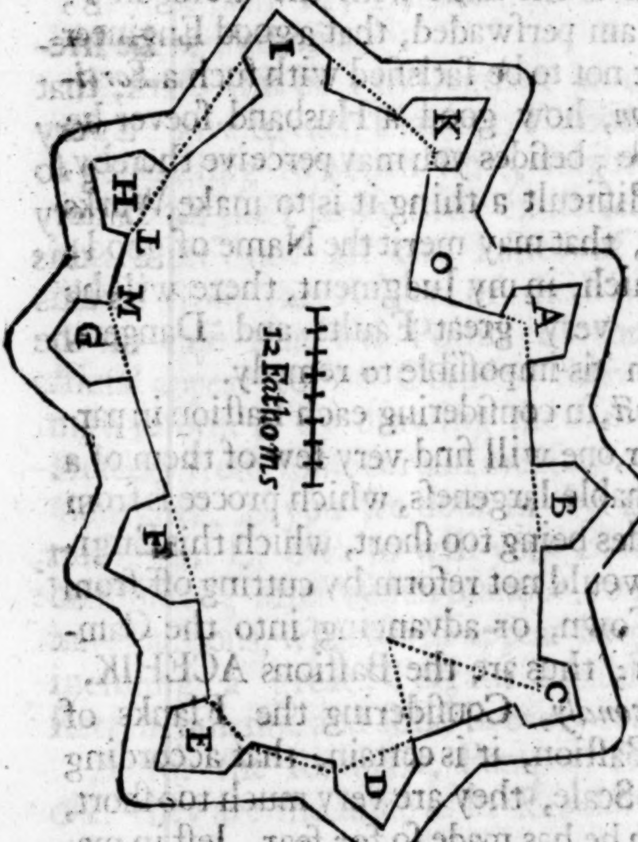
If the Town ſhall be found incompaſſed with old Walls, one muſt not touch them, except they be cut in ſome places by the Fortifications. The Ground found in the Augmentation will ſerve for to make Barracks for Soldiers, places of Arms, Magazines, *&c.*

This Town may be fortified after another manner, as in the following Figure, which is the ſame with the aforegoing; but I am perſwaded, that a good Engineer ought not to be ſatisfied with ſuch a *Fortification*, how good a Husband ſoever he may be; beſides you may perceive thereby, how difficult a thing it is to make Works there, that may merit the Name of good; in which, in my Judgment, there will be found very great Faults and Dangers, which 'tis impoſſible to remedy.

Firſt, In conſidering each Baſtion in particular, one will find very few of them of a reaſonable largeneſs, which proceeds from the ſides being too ſhort, which this Engineer would not reform, by cutting off from the Town, or advancing into the Campaign; thus are the Baſtions ACEHIK.

Secondly, Conſidering the Flanks of each Baſtion, it is certain, that according to his Scale, they are very much too ſhort, which he has made ſo for fear, leſt in making them longer, the flanked Angle becomes too acute; for as much as the flanked Angle of the Baſtion follows the nature of the Gorge, which being too little, makes alſo the flanked Angle too acute, which diminiſhes as much more as one prolongs the Flanks of the Baſtions;

this



this is evident in the Baſtion E, where the Gorge being no more than 90 Degrees, which is the Angle of the Square, if one raiſes the Flank never ſo little, the Point of the Baſtion notably diminiſhes, and become leſs proper to reſiſt a long time; the ſame may be remarked in the Baſtions A, C and K.

Thirdly, One that will follow the Irregularity of the Figure, may remark, that the Baſtions F and G, fall into a very great Fault, the Flanks of each being ſo very open or diſcovered, that any Battery of Cannon cannot there be ſecure; this the Engineer is obliged to make after this manner, for to ſhoot more direct on the Counterſcarp, and to render the Merlons more ſolid; for as much as each of them are flat Baſtions, of which we ſhall hereafter ſpeak.

Fourthly, The ſide LM, being too ſhort, has cauſed to be made two Baſtions, ſo cloſe the one to the other, that the height of the Rampart, and thickneſs of the Parapet, will abſolutely hinder the view of the Counterſcarp and Ditch, which is manifeſt.

Fifthly, The re-entring Angle O, which appears to be the moſt ſecured, becauſe of the Baſtions A and K, which defend it from reverſe, it is ſo diſcovered, that it is preſently ruined by the Fire of the Enemy, as are the oppoſite Faces of the Baſtions A and K.

Sixthly, The flat Baſtions B F G, being placed on a Right-Line, have two Faults.

The Firſt is, That if their Flanks do not make with their Courtain, a very obtuſe Angle, they cannot batter on the Counterſcarp, and then they are ſo much diſcovered by the Enemy, they alſo thereby diminiſh very much the Faces, as likewiſe the Terrain.

The other Fault is, That the Ditch being drawn parallel to the Faces of the Baſtions, the Flanks will not diſcover the Ditch of the oppoſite Baſtion, if it be not augmented very much before the Courtain, which is a conſiderable Expence; this is what may be remarked in the Ditch from the Baſtion K, to the Baſtion G, that the *Author* has been obliged to augment the Ditch before each Courtain, tho' with little or no Advantage, not any one Flank diſcovering intirely the Ditch of the next Baſtion; the ſame you will find from the Baſtion E, to the Baſtion G, where the Ditch is alſo inlarged before the Courtain.

From all which it is evident, That it is no doubt the ſureſt and beſt Method to incloſe a place in a Polygon, as regular as is poſſible.

When the Town is of a very large extent to leſſen the number of the Baſtions, and conſequently the Expence, after having incompaſſed it in a Circle, or in a ſort of an Oval, as aforeſaid, one may fortifie it according to the Method of Chevalier *de St. Julien*, for fortifying large Towns.

If the Intention in fortifying of a place be only to free it from Inſults; to perform which, one ought to remember theſe firſt Maxims, *viz.* That one Work always flank another, that there be nothing that is not ſeen from the Place, and diſtant from thence above Musket-ſhot. Obſerving which Maxims, one ought to content himſelf to incompaſs ſuch a place with ſome Ravelins, ſuch as we have deſcribed, giving from 40 to 50 Fathoms, for their Capital, and taking care that their Faces be not only defended by the next Ravelins, but alſo from ſome Tower, and ſome advantagious part of the place, where one can lodge Musketeers, and ſome pieces of Cannon, round about all digging the Ditch, and incompaſſing the whole with a Covert-way, furniſhed with Traverſes and Places of Arms, with a large Glacis, and this is what is moſt neceſſary; and if one can bring the Water out of the

Country into the Ditch, as it happens in Watry Countries, it would be much better.

If the place be already fortified after a manner that is of little force, ſuch as one finds very often, eſpecially amongſt thoſe that have been built an Age ago, in the which one often finds the Baſtions too little, the Courtains too long, and the Ditch too ſhallow, the Covert-way without Places of Arms, the Glacis but of 9 or 10 Fathoms broad; then in following the general and particular Maxims, which we have before given, the Engineer ought to reform all the parts thereof, inlarging the Baſtions, which he finds too ſtreight, by their Gorges, or the Flanks too ſhort, or too much expoſed, in ſuch ſort, that they be near the largeneſs of thoſe which are in a Regular Fortification; to which effect he ought to make uſe of the Materials of the Ancient Baſtions, without touching any part of its Earth, which being old and well ſetled, which is always better than the new; for that which has the Courtain too long, but not of too exceſſive a length, the Lines of Defence ought to be ſhortned by Tenails in the Ditch, as in Monſieur *Vauban*'s Method, or otherwiſe by *Caponieres*, as in Monſieur

St. Julien's Method. Thus having reformed all the parts of the Body of the Place, and alſo the Ditch which ought to be near 20 Fathoms broad, and near 3 Fathoms deep; each Courtain muſt be covered with a great Ravelin, incompaſſed with a Ditch of 10 or 12 Fathoms broad, drawing the Faces of the Ravelin towards the Angle of the Epaul of each Baſtion next to it, or otherwiſe a little on the Face, to the end that the Flanks be covered, and that nothing be wanting to a good Defence.

The reſt ought to be examined following the Method for the Covert-way and Glacis, as ordinary; and this is what regards a place where the Ground is free from inconvenience without.

Here follows the Circumſtances without, or at leaſt the moſt conſiderable of them.

If the Place to be fortified, be built on the brink of a River, deep, wide, and rapid; incompaſs it with a Demi-circle, or Demi-oval, according to its Figure, and fortifie it according to the Method before ſhewn, above all, taking care, that the Extremities of the Place, on the brink of the Water, be well covered, and well fortified, for as much as it is always the weakeſt part; as for the ſide next the Water, good Platforms to hinder the Aſcent, will be ſufficient.

☞ Note, *Platforms are Elevations of Earth, ſquare, covered with their Parapets, which generally ſerve only to ſhoot direct; alſo all thoſe Works in a Fortification, built in a re-entring Angle, are called Platforms.*

But if the River be very broad, and runs croſs the place, it ought to enter in, and go out through a Courtain, that the Entrance and going out, may be defended by the two oppoſite Flanks of the Baſtions.

But if the River be broader than the length of a Courtain, and divide the Town, one muſt incompaſs the Town by two Demi-circles, or Demi-ovals, and fortifie them ſeparately.

If the place be ſituated on the Sea ſide, the ſide next the Land being fortified, as before ſhewn, the ſide next the Sea muſt in no wiſe be neglected, eſpecially if the Sea is not very deep; but make very good Batteries, ſuch as may very well ſecure ſuch Sides, becauſe often great Froſts in

Winter, or a very dry Summer, is often dangerous to ſuch Places.

If there be found about the Place, any height diſtant from the Town Cannon-ſhot, do not regard it, but if it be nearer, it muſt be raced if poſſible, or otherwiſe ſecured by ſome Fortreſs or Advance on that ſide; ſome Work a Horn-work with good Cavaliers on the Head of it, or it muſt be cut ſo, as it will be difficult to deſcend from it, or aſcend to it; and on the Baſtions on that ſide, raiſe good Cavaliers, and good Traverſes to cover the Soldiers.

If the Place be on an acceſſible Mountain, fortifie the Deſcent rather than the Top, for it often happens, that the Mountain affords Covert to the Enemy, juſt at the Palliſadoes; the beſt way therefore, no doubt, is to make on the Deſcent inforced Ravelins, one before the other, unto half the Deſcent, with their Ditches and their Covert-ways, and above make a Citadel interred, making uſe of the Earth rather to make the Glacis of the Covert-way, than to raiſe the Baſtions, which will be both leſs expenſive and leſs troubleſome.

CHAP. XVI.

The Conſtruction of Citadels.

THAT which is called a Citadel or Caſtle, is a ſmall Fortreſs ſometimes of 4 or 5 Baſtions, ſometimes (tho' but rarely) of 6; and becauſe the Square is too imperfect, and the Hexagon is too large, the beſt are thoſe of 5 Baſtions, ſo placed, that the Courtain and 2 Baſtions command the Town; for they are generally not only built for the better Defence of the Town, but alſo to prevent the Mutiny of the Inhabitants thereof; for which reaſon the Citadel ought to command all the Town, and to that end they muſt be placed on the higheſt part about the Town, and joyned immediately thereto; and the Fortification of that part of the Town next the Citadel, is to be demoliſhed and diveſted of Houſes unto to the Center; and the Citadel on that ſide, well fortified with a good Covert-way and Glacis, which, without doubt, is the beſt ſituation for a Citadel, becauſe it can better keep the Inhabitants of the Town in ſubjection, and hinder their having Intelligence with the Enemy; for which reaſon the Citadel ought not to be ſeparated from the Town, without an abſolute neceſſity; as when the Place is compaſſed with ſeveral Heights or Hills, then it is to be placed on the higheſt, for to ſave the Expence of levelling them; or in Sea-Ports, where there is a Place that will command both the Town and Harbour.

If the Citadel be diſtant from the Town, leſs than Musket-ſhot, then the two Flanks and the Conrtain, that regards the Citadel, ought not to have any Rampart or Parapet, but only a ſimple Wall, to the end that the Citadel may better command the Town; and the Town and Cittadel muſt be joyned on one ſide, and the other with a Rampart, with its Parapet and Ditch drawn from that part of the Ditch of the Citadel that is over againſt the Point of each Baſtion, to that part of the Ditch of the Town, over againſt the Points of the Baſtions thereof, to cover the Space betwixt the Town and the Citadel, that the Soldiers may paſs from one place to the other under covert.

But if the Citadel be diſtant from the Town more than Musket-ſhot, that ſide of the Town, next the Citadel, muſt be fortified.

When the Citadel is built upon a very high Hill or Rock, where ſome ſides are ſo ſteep, that it is impoſſible to get up on thoſe ſides, there are no occaſion for any Fortification; it is ſufficient there only to make a Parapet for to hinner the Soldiers from falling down; but on the other ſides that are acceſſible, it is not ſufficient only to fortifie the Top, but alſo two thirds of its Deſcent by Demi-Lunes inforced, or ſome other Work, as Horn-work, which ought to be Intrenched in the Hill, thereby to render the Enterprize of the Enemy more difficult.

The middle of the Town, is by no means a good place for a Citadel; for as much as being incloſed on all ſides, if the Town be taken, there can be no hopes of Succour.

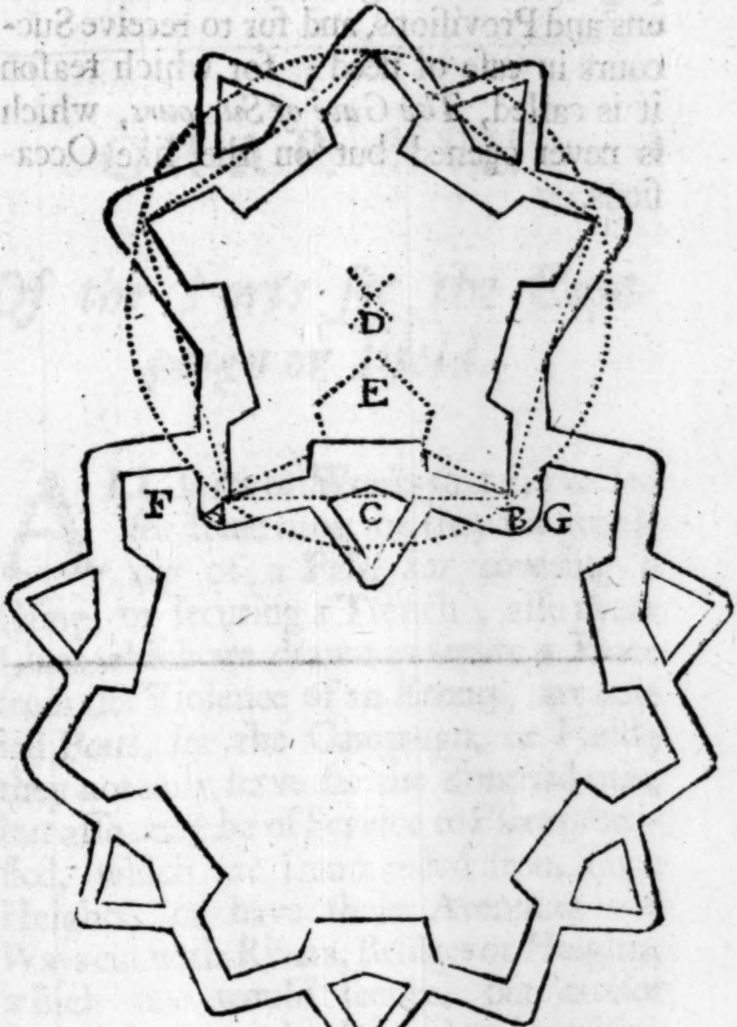
Many have been of Opinion, that the meaſure for Citadels, ought to be leſs than the common meaſures that are given to

Polygons, and that one ought to ſhorten all the parts, making the ſide of the Polygon ſhorter, and all the Parts proportionable, *viz.* the Baſtions leſs, and the Courtain ſhorter.

Thus formerly was the Citadel of *Charleville*, and other Places, but they are now convinced of this Errour, for as much as there muſt be as great a Garriſon to defend a little Pentagon, as a greater; and beſides, the Gorge being ſtrait, the Flanks ſhort, and the Baſtions too little, are not at preſent of any Defence; for which reaſon a Citadel muſt be made of the ſame Grandure as other Forts of the ſame number of Sides, the Proportions of which, we have given you in the aforegoing Tables; and thereby you will have all the Advantages which one can deſire in a Fortreſs.

I ſhall therefore proceed to give you an Example of a Citadel joyned to the Town.

Having deſtroyed one of the Baſtions, as E in *Fig.* 18. draw from the Angle of the Flank of the Baſtion F, to the Angle of the Flank of the Baſtion G, the Line AB, which divide into 2 equal parts, in the Point C; and from C, place on both ſides half the ſide of the Exterior Polygon. In the aforegoing Tables, according to Monſieur *Vauban*'s Method, you will find the ſide of the Exterior Polygon, to be 180 Fathoms; ſo that having placed 90, the half thereof from C, to A and B; then with the great Radius of the Figure, which, for a Pentagon you will find in the ſame Table to be 135 Fathoms and 1 Foot; with one Foot in A and B, make the two Arches interſecting each other in the Point D, which will be the Center of the Circle; which from D, with the diſtance D A or D B, being deſcribed with the diſtance A B, or 180 Fathoms; divide it into 5 equal parts, drawing the Sides, *&c.* and fortifying it in every reſpect, as has been ſhewn in the Conſtruction of Monſieur *Vauban*'s Method, as if it was a Town of the ſame number of Sides, as well within as without, making the Faces of the Baſtions of the Town F and G, to terminate on the edge of the Ditch of the Citadel, as you ſee in the Figure, joyning the Ditches, Covert-ways and Glacis together.



The Citadels have generally but two Gates, one of which is in that ſide next the Town, and the other towards the Campaign,

paign, for to bring in thereat Ammunitions and Proviſions, and for to receive Succours in caſe of need ; for which reaſon it is called, *The Gate of Succours*, which is never opened but on the like Occaſions.

CHAP.

CHAP. XVII.

Of the Forts for the Campaign or Field.

ALL ſorts of Works that are raiſed for ſome time, be they for guarding of a Paſs, for covering a Camp, or ſecuring a Trench ; alſo thoſe Lines which are drawn to ſecure a Place from the Violence of an Enemy, are called Forts, for the Campaign, or Field ; they not only ſerve for the aforeſaid uſes, but alſo may be of Service to Places fortified, which are commanded from ſome Heights, or have their Avennues and Ways cut with Rivers, Bridges or Heights, which one would ſecure, but cannot ſometimes better be done, than by raiſing near them Forts for the Campaign, which has obliged me to give their Conſtruction here.

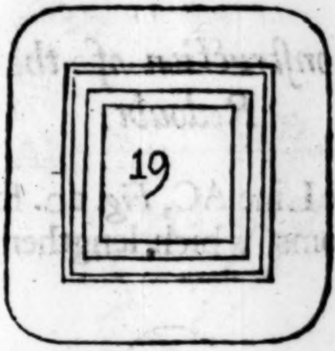
The little time in which generally theſe ſort of Works are required to be compleated, is the reaſon that generally they do not give them neither a great Elevation, nor a very deep Ditch; contenting themſelves with ſlight Works, ſuch as may be capable to ſuſtain the Soldiers for ſome Hours, but the Diſcretion of the Engineer will inform him to add to their ſtrength, as there ſhall be occaſion.

The moſt common of theſe Forts, are the Square Redoubt, the Square with Demi-Baſtions, the Star Pentagon and Hexagon, and other ſtrange Figures, which have no more force than a ſimple Redoubt.

I ſhall here give the ordinary Conſtruction of theſe ſort of Forts, as they are made on the Lines of Circumvalation, and on Lines that are drawn to ſecure a Place againſt the Violence of an Enemy.

The Conſtruction of a Redoubt.

Draw upon the Earth, a Geometrical Square, as in *Fig.* 19. following each ſide being from 12 to 20 Fathoms, as there ſhall be occaſion.



Within which Square place 17 or 18 Feet for the Baſe of the Rampart, which ought to be built above the level of the Campaign or Ground, 3 or 4 Feet, or higher, as there is occaſion.

Make the Parapet upon the Platform or Terraſs of the Rampart, of 9 or 10 Feet thick, and 6 or 7 Feet high behind, with its Banquet, and 4 Feet before.

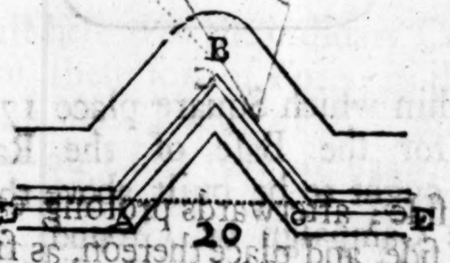
About the Rampart leave a Space, or Berme, of 3 Feet.

Then about the Berme, dig the Ditch of 5 Fathoms wide, and 8 or 10 Feet deep, with the Earth of which, make the Rampart and Parapet.

The Bridge for to enter into the Redoubt, ought to be 10 Foot broad, when Cannon is to be placed therein; but otherwiſe 5 Feet broad will be ſufficient.

The Conſtruction of the Half Redoubt.

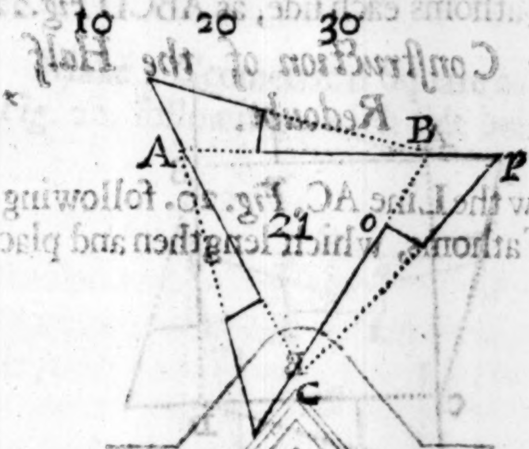
Draw the Line AC, *Fig.* 20. following; of 20 Fathoms, which lengthen and place on both ſides from A to D, and from C to E, 10 Fathoms, and make the Faces A B, and C B, each 15 Fathoms.



The Berme, Ditch, Rampart, and Parapet, *&c.* muſt be the ſame as that of the Redoubt.

The Conſtruction of a Triangle with Demi-Baſtions.

Make an Equilateral Triangle, as ABC, in *Fig.*21. following, of 24 or 25 Fathoms

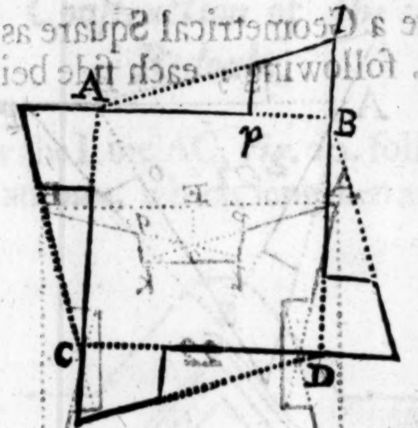


each ſide; afterwards prolong each contrary ſide, and place thereon, as from P to B, the third part of each ſide, or 8 Fathoms, for the Capital; likewiſe the ſame diſtance on each ſide of the Triangle, as from B to *o*, for the Demi-Gorge, and raiſe the Flanks Perpendicular to the ſides of the Triangle of a convenient length, which ſhall be determined by a Line Raceing, drawn from the Point of the

the Triangle, to the end of the Capital; the reſt is the ſame with the Redoubt.

The Conſtruction of a Square with Demi-Baſtions.

Make a Square on the Ground, of 24 or 25 Fathoms each ſide, as ABCD *Fig.*22.

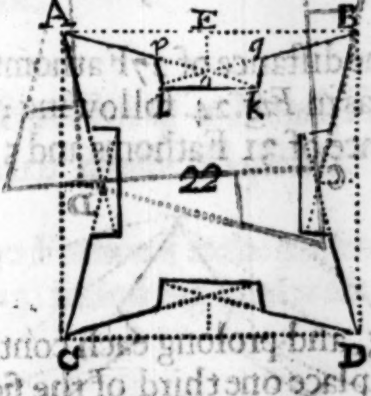


following, and prolong each contrary ſide, on which place one third of the ſide of the Square, or 8 Fathoms for the Capital, as from B A to 1; alſo place the ſame diſtance on each ſide of the Square for the Demi-Gorge, as from B to *p*; from whence, as from *p*, draw the Flanks perpendicular to the ſides of the Square, the Length of which will be determined by a Line

Raceing, drawn from the Extremity of the ſide of the Square, unto the end of the Capital; the reſt is the ſame with the Redoubt.

The Conſtruction of a Square with whole Baſtions.

Make a Geometrical Square as ABCD, *Fig.* 23. following; each ſide being near



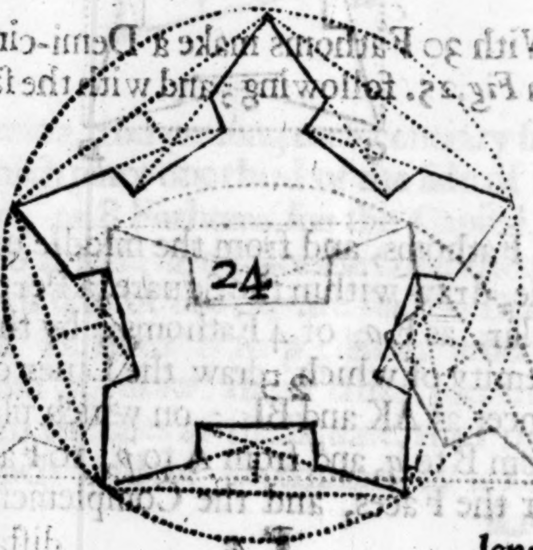
31 Fathoms, and from the middle of each ſide, draw within the Square, a Perpendicular, as E *o*, of 4 Fathoms; by the Extremity of which, draw the Lines of Defence, as AK and BL; on which place, as from B to *q*, and from A to *p*, 10 Fathoms for the Faces, and the Complements are

found by placing the diſtance from *p* to *q*, from *p* to K, and from *q* to *l*, as before ſhewn, which done, draw the Flanks and joyn them together for the Courtain.

The Baſes of the Rampart muſt be near 5 Fathoms, and the Parapet 14 or 15 Feet, the Berme 3 Feet, the breadth of the Ditch 6 Fathoms, and 8 or 10 Feet deep.

A Conſtruction of a Pentagon with whole Baſtions.

With the diſtance of 27 Fathoms, deſcribe a Circle, as in *Fig.* 24. following; and with the diſtance of 31 Fathoms and 5 Feet, the

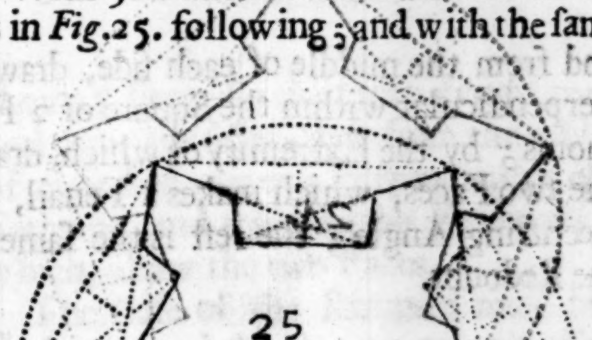


length of one of the ſides, divide it into 5 equal parts, and draw the ſides; then from the middle of each ſide, draw within the Pentagon, a Perpendicular of 5 Fathoms, by the Extremity of which, draw the Lines of Defence; the Faces muſt be 10 Fathoms, and the Complements muſt be found, as in the Square before going.

The Rampart muſt be 5 Fathoms thick, and the Parapet 12 or 15 Feet, the Ditch 5 or 6 Fathoms wide, and the reſt as in the Redoubt.

The Conſtruction of a Demi-Hexagon with whole Baſtions.

With 30 Fathoms make a Demi-circle, as in *Fig.* 25. following; and with the ſame

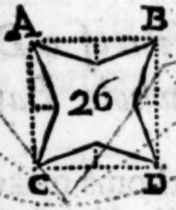


25

diſtance, divide it into 3 equal parts, and draw the 3 ſides, and from the middle of each of them, draw a Perpendicular of 5 Fathoms; by the Extremity of which, draw the Lines of Defence, and thereon place 8 or 9 Fathoms for the Faces, the reſt are in every reſpect, as in the Pentagon aforegoing.

The Conſtruction of a Star Square.

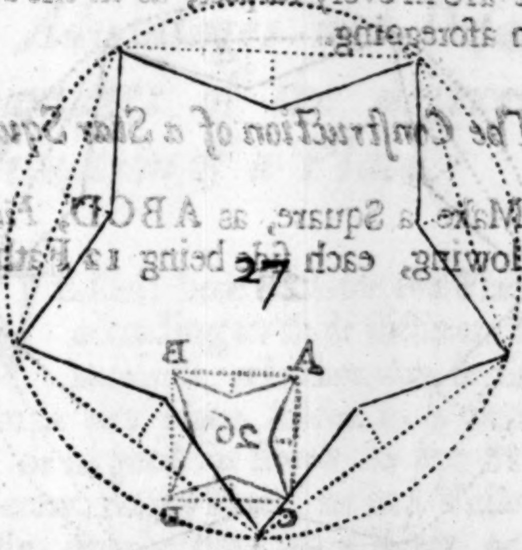
Make a Square, as ABCD, *Fig.* 26. following, each ſide being 12 Fathoms;



and from the middle of each ſide, draw a Perpendicular within the Square of 2 Fathoms; by the Extremity of which, draw the two Faces, which makes a Tenail, or Reentring Angle; the reſt is the ſame as the Redoubt.

The Conſtruction of a Star Pentagon.

With 27 Fathoms make a Circle, as in *Fig.* 27. following; which with 31 Fathoms 5 Feet, divide it into 5 equal parts, and draw the ſides; then from the middle of each ſide, draw a Perpendicular of 5 Fathoms, and towards the Extremity of which, draw the two Faces.

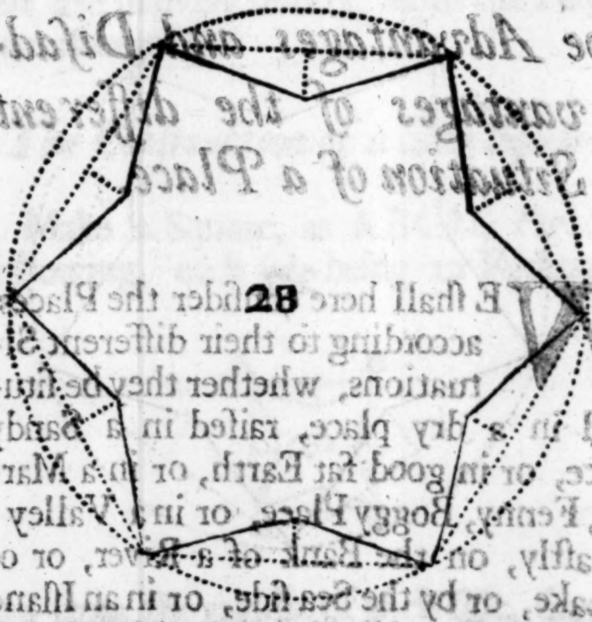


The Baſe of the Rampart muſt be 5 Fathoms, and the Parapet 12 or 15 Feet, the Ditch 5 or 6 Fathoms broad; and the reſt as in the Redoubt.

The

The Conſtruction of a Star Hexagon.

With 30 Fathoms make a Circle, as in *Fig.* 28. following; and with the ſame



diſtance, divide it into 6 equal parts; and on the middle of each ſide, draw a Perpendicular of 5 Fathoms, and to the Extremity thereof, draw the Faces; the reſt are as in the aforegoing.

CHAP.

CHAP. XVIII.

The Advantages and Diſadvantages of the different Situation of a Place.

WE ſhall here conſider the Places, according to their different Situations, whether they be ſituated in a dry place, raiſed in a Sandy place, or in good fat Earth, or in a Marſhy, Fenny, Boggy Place, or in a Valley; or laſtly, on the Bank of a River, or of a Lake, or by the Sea ſide, or in an Iſland or other Places incompaſſed with Water; all which ſeveral Situations, have their *Advantages* and *Diſadvantages*, as follows.

Of

Of Places ſituated on high Hills, Rocks, &c.

The *Advantages* of a Place ſituate on a Mountain, Hill, or Rock, are as follows.

Firſt, The Air there is always good.

Secondly, It cannot be undermined, but with much difficulty.

Thirdly, If the Fortification occupy all the top of the Hill, *&c.* it is more troubleſome to the Enemy than any other, becauſe it ſo diſcovers all round their Traverſes, that in their Approaches, they cannot raiſe any Works, but what is commanded by the Place; they are conſtrained to make their Trenches very high, that they may not be ſeen from the Place; and alſo the Parapets of their Batteries extraordinary high, to the end that the Cannons be covered in their Recoil, for whatever they do, is always in ſight of thoſe of the place, which they cannot ſee,

Fourthly, Mountains are of themſelves ſo ſtrong, that they do not require much Pains to aſſiſt Nature by Art, ſo that the Fortifications of ſuch Places may be done with little Expence, it not having need of a high Rampart or Parapet; and as one cannot generally enter therein, but by one or two ways, one is obliged to fortifie and defend only ſuch ſides where it is acceſſible, for where the place is inacceſſible, the Enemy cannot then force it; and if therein be put a good ſtore of Proviſions, and Ammunition, it can be kept a long time without a large Garriſon to defend it.

Laſtly, In Sallies, thoſe of the place have the Advantage of being and keeping the higheſt Ground.

The *Diſadvantages* of a Place ſituate on a high Hill or Rock, are,

Firſt, The Place is generally ſmall, eſpecially when it is placed on the top of a Hill, or Rock; ſo that one cannot build but ſome Caſtle which cannot be of much force or reſiſtance; and if one can build a conſiderable Fort, it is very difficult to make it Regular, becauſe of the careleſs Figure which Nature ſeems to have given to thoſe ſort of Places, that what care ſoever one takes, it is ſometimes impoſſible to make it of a more Regular Form. Theſe Places generally want Earth for the Fortifications; the height and thickneſs of which, facilitates the Approaches, becauſe it is difficult to ſhoot from above, below, whilſt the Parapet is of a due thickneſs with a Musket, much more with a Cannon, which doth much more Execution, being ſhot from below than from above, as is eaſily conceived, beſides the difficulty of bringing Proviſions and Ammunition thither. Such like Places generally want Water, which Defect is generally ſupplied by Ciſterns being made to catch Rain Water. Theſe Places are ſubject to be ſurpriſed, becauſe the Garriſon being ſmall, and confiding in the ſtrength of the Place, often neglect to keep a good Guard, and eſpecially, as I have ſaid before in *Chap.* 15. if the top only be fortified, being ſuch Forts generally afford Covert to the Enemy, juſt at the Palliſadoes, in which Place I have ſhewn the beſt Method to fortifie Places ſo ſituate, to remedy moſt of the aforegoing *Diſadvantages*, to which I refer the Reader.

Laſtly, The Earth being generally Sandy, is not proper for Fortifications, becauſe it cannot long endure, as well becauſe of the Rains, which ſoon deſtroy it, as becauſe it is ſoon demoliſhed by the Cannon of the Enemy.

Of Places ſituate on a Deſcent.

Theſe Places ſo ſituate, are by conſequence commanded, and therefore defective and difficult to fortifie; the Place commanding, ought, if poſſible, to be incloſed in the Fortification, or otherwiſe, as we have ſaid before, in *Chap.* 15. ought to be ſecured, or a Caſtle or Citadel placed upon it.

Of Places ſituate in a Valley incompaſſed with Mountains on all ſides.

Theſe Places are ſo defective, that it is better to let them alone, than to endeavour to fortifie them, becauſe whatſoever one doth, the Enemy being lodged on the Heights, will annoy the Country and the Place with their Cannon.

Of

Of Places ſituate in a Plain.

The *Advantages* of Places ſituate on a Plain, are,

Firſt, The Extent of the Campaign or Country, which one has to make a Fortreſs in at pleaſure, where one can make the Fortifications Regular, agreeable to the Capacity of the Place, when the Campaign is even. As the Earth there is generally good and ſlimy, one can therewith make not only a good Rampart, Parapet, Cavaliers, *&c.* but alſo more eaſily make Intrenchments, when attacked. The Earth round the place being fruitful, affords Neceſſaries to the Place, as well for Men as Beaſts.

Laſtly, Such a place is very proper for Commerce, eſpecially when it is built by a River-ſide, which facilitates the bringing thither all things neceſſary.

The *Diſadvantages* of a Place ſituate on a Plane, are,

Firſt, The Enemy enjoys the ſame *Advantages* as thoſe of the Place, who becauſe the Earth is good, and will very eaſily make their Lines of Circumvalation and Approaches, and the Fruitfulneſs of the Earth affords them wherewithal to ſubſiſt their Army, particularly their Horſe; and they enjoy moreover more of the Fruits of the Country, than thoſe of the Place, which are ſhut up.

Laſtly, The Earth being fat, is more proper to make the Mines, and conſequently the Place is expoſed on all ſides.

Of Places ſituate in a Marſhy, Fenny, or Boggy Place.

The Places which are ſituate in a Marſh, Fenn, or Bogg, and incompaſſed on ſeveral ſides with Water, are very ſtrong, and have this *Advantage*, That it cannot be Attacked but in few Places, which may be well fortified by advancing ſeveral Works one before another, in ſuch ſort, that the greateſt Work be oppoſite to the ſide of the Enemy, for to hinder their Approaches.

Moreover, The Place has no need but of a ſlight Fortification, and of a little Garriſon, becauſe the Beſiegers cannot eaſily make their Batteries, nor Lines of Approaches, being conſtrained to bring their Earth from other Places.

Laſtly, ſuch Places are generally exempt from Mines.

The *Diſadvantages* of a Place ſituate on a Marſh, Fenn, or Bog, are,

Firſt, That the Air there is unhealthful; and when one would fortifie it well, it is very expenſive, becauſe one doth not there find Earth enough for the Fortifications, for one in digging the Ditch, ſoon meets with Water, which obliges one to bring Earth from other Places; and the Foundation is ſo ſoft, that very often the Baſtions ſink into the Earth, and are ruined of themſelves; at leaſt, if they be not built on good Piles, as at *Amſterdam*, the Enemy can very eaſily block up the Paſſages, and the Marſh, Fenn, or Bogg, can often be drained, by the cutting of ſome Gutters, and breaking of ſome Banks, or opening of ſome Sluce ſituate near the Town, of which the Enemy can eaſily render themſelves Maſter, to the prejudice of the Place. But when one fears that, he ought to cover thoſe Marſhes, Fenns, or Boggs by Forts, for to repulſe the Enemy, and to hinder them from undertaking any thing on that ſide.

There are certain Places in *Zealand*, and part of *Holland*, where the Country or Ground lies ſo low, that one can eaſily overflow all the Country, when one will by cutting the Banks, as was done at *Landercy*, where a great part of the *Spaniſh* Army that Beſieged it, was drowned. But to many of thoſe ſort of places ſituate on Marſhes, Fenns, or Boggs, an exceſſive dry Summer, or a very hard Froſt, often proves of fatal Conſequence.

Of Places ſituate on the Sea ſide, or on the Bank of a River.

The Towns ſituate on the Water-ſide, have the *Advantage* of not needing a great Garriſon; and that ſide next the Water, may often be fortified with little charge; one there can alſo, with little charge, bring Proviſions and Ammunition, and all other Neceſſaries, particularly to the Sea Ports. Becauſe the Naval Force cannot always continue before the Place, becauſe of Tempeſts; the Enemy muſt have a great Force to render themſelves Maſters of ſuch a Place; for they muſt neceſſarily Beſiege it by Sea and by Land; and the nearneſs of the Sea and River renders a Town commodious for Arts and for Trade.

The *Diſadvantages* of thoſe Places, are,

Firſt, If they are as thoſe of *Zealand* and *Holland*, the Enemy being rendred Maſters of the Banks, in opening them, they can put under Water, all the Country, to the great Prejudice of the Place; likewiſe they having ſeized the Banks and the Sluces, which govern the Courſe of the River, they can by raiſing them, hinder the Courſe of the Water, and put all the Town, or at leaſt, the greateſt part of it under Water. The River and the Sea affords to the Enemy, by means of their Veſſels, the ſame Advantage as thoſe of the Town, who have to fear not only the Enemy near, but alſo thoſe farther off, which can ſurprize the Place by a Fleet unexpectedly. The Enemy can, with little trouble, block up a River with ſome Veſſels, or Pontons, and by that means hinder Succours of Proviſions, and of Men, which the Garriſon may hope from that ſide.

Laſtly, It doth not always happen, that ſuch a Place can be commodiouſly fortified, and at ſmall charge, as well becauſe of the Bridges, the which it cannot paſs, as becauſe of the detached Works, which one is often obliged to make from thence in the River, for to guard the Town on that ſide, and many other Works, as Banks, Gutters, Sluces, Mills, ſtrong Palliſadoes, and other things neceſſary to oppoſe the Violence of the Enemy.

Of Fortreſſes ſituate in an Iſland.

The Fortreſſes which are made in an Iſland, diſtant from the Continent, or main Land, Cannon-ſhot, or more, has this *Advantage*, That they are not ſubject to the Effort of the Artillery, which, at ſuch a diſtance, cannot do it any damage; but the Cannon of the Veſſels of the Enemy, can extreamly incommode it. The Inhabitants of the Iſland, can eaſily hinder the Deſcent of the Enemy; but they may alſo as eaſily be ſurprized by the Enemies Fleet.

Laſtly, The Place there, provided that the Earth is good, can be eaſily fortified, and with little Charge, otherwiſe the Expence will be conſiderable; beſides which, for to reſiſt the Sea, or the Impetuoſity of a River, one is often obliged to raiſe the Banks and Points of Earth.

Of the Choice of a Place to Fortifie.

By the *Advantages* and *Diſadvantages*, which happen in the different ſituation of a Place; and from what follows, it is eaſie to make choice of a Place the moſt agreeable for to build a Fortreſs.

One ought principally to endeavour to have a good Temperature of Air, and plenty of Water, becauſe a bad Air cauſes the Plague; and corrupt Water, Agues, Feavers, Scurvy, and other Diſtempers, which ſoon entirely ruin the Garriſon afflicted therewith.

One muſt chuſe a ſituation as Advantagious as is poſſible, in ſuch ſort, that the Place commands without being commanded; that it be difficult to Beſiege; and in caſe of a Siege, it can be ſuccoured in ſpight of the Enemy.

And Laſtly, That the Earth be good for making the Works.

CHAP. XIX.

Of Tracing the Draught of a Fortification in the Field.

TO the tracing the Plane of a Fortification in the Field, is generally the Subject of a Chapter in moſt Treatiſes of *Fortification*, but it appearing to me ſo eaſie a thing, for a Perſon that has but a very ſlender knowledge in the *Art of Surveying*, can as eaſily lay down an Angle upon the Earth, with a Demi-circle, or other the like Surveyers Inſtrument upon the Ground, as with a Protracter upon Paper; and as for drawing of ſtrait Lines, by the help of Pickers and Cords, or other ſort of Thread, or Line, and Perpendiculars, by the help of a Line and a Square, and conſequently Parallel Lines, they are things commonly known, and very eaſie to perform: Beſides, having in the *Geometrical Problems* at the beginning of this Book, ſufficiently treated of all thoſe

Matters, by the help of which, any Fortification may be laid down upon the Ground, with as much eaſe and certainty, as with the Compaſſes and Ruler upon Paper; for Brevity ſake, I have omitted, to inſert it here, and ſhall proceed to give the Method how to raiſe the Rampart, Parapet, *&c.*

How to raiſe the Rampart with the Parapet, &c.

Having firſt made an exact Draught of the Fortification upon Paper, and tranſferred the ſame upon the Earth, when its deſigned only to Gazonage, or Coat the Work with Gazons, or Turfs, cut in form of a Coyn of Wood, ſuch as one raiſes the Breech of a Cannon with, repreſented in *Fig.* 29. by A B C D E; whoſe length A D, muſt be 15 Inches; and breadth A B, 6 Inches; and its thickneſs B C, at the thick end, which is put outermoſt, 5 Inches; as for the thickneſs of the other end D E, it is not determin'd, becauſe it depends upon the Talus which is given to the Rampart.

In Fortifications of this kind, there is occaſion for no other Foundation, than the Earth it ſelf; on the which one muſt place the firſt row of Turfs with the Graſs downwards, or next the Ground, faſtening them well with Pickets, or wooden Pins to the Ground, as along the Line A B, in *Fig.* 30. And on the Top of which row of Turfs muſt be placed a ſecond, ſo as that a row of Turfs covers the Joynts of the former; and on the ſecond, muſt be placed a third; and ſo on to the height of the Rampart, laying them all with the Graſs downwards, ſowing on the Top of each Row, ſome Seed of a Herb that produces the moſt Roots: And moreover, each Turf muſt have one or two good wooden Pins drove through them, for the better laying and faſtening them together, the one to the other; and between each row of Turfs, place Horizontally little Twigs of Green Willows; ſo that the ſmall Ends appear without, which will ſerve to lay the Turfs, the out ends of which, may afterwards be cut off, even with a Spade.

The empty Spaces which ſhall be found betwixt the rows of Turfs, muſt be filled with the Earth taken out of the Ditch, trod and well beaten down with Rammers,

mers, which are round pieces of Wood, of 5 or 6 Feet long, and ferrelled at each end, with two handles about the middle thereof, or otherwiſe they may be made ſmall at one end, juſt like thoſe the Paviers make uſe of to drive down the Pavement; whilſt they work at the Sodding or Turfing, the Earth of the Ditch muſt be opened between the Scarp and the Counterſcarp, which muſt be as has before been obſerved, 15 or 16 Feet deep, which muſt be carried in Baskets, and in Wheel-Barrows, to all the Parts of the Rampart.

In digging the Ditch, there muſt be obſerved two things:

Firſt, That there be left from place to place, Heights of Earth like Pyramids, which ſerves for to meaſure its Depth.

The Second is, That the Sodd-work, or Turf-work, which is made ſimply on the Earth without a Foundation, requires a Talus of 3 Feet, with a Berm of 3 Feet, to ſeparate it from the Brink of the Ditch.

In digging the Ditch, there muſt be given to it a reaſonable Talus, or Slope, which is generally equal to the height, or more, if the Ground be Sandy. As for the Talus of the Rampart, it muſt be altered

tered according to the Nature of the Earth, tho' I find the outward Talus is generally made equal to half the height, and the inward equal to the height.

To the end that the Earth may better joyn, it muſt be a little Wet, that a Foot in height may be reduced to 7 or 8 Inches; and for the better preſerving a juſt Talus, one muſt make uſe of a Level, as GDEF, of which the ſide DF, is equal to the leaning of the Talus; ſo that by applying the ſide DF to the Work, ſo that the Thread GH, falls on the Line, which ought to be parallel to the ſide CE, one may make an exact Talus.

The *Terre-plain*, or Walk of the Rampart, muſt be made a little ſhelving towards the Town, as well that the Water may run off it, as for the Cannon more eaſie recoyling out of the ſight of the Enemy, and it is generally made near a Foot higher than it ought to be, becauſe of its ſinking with the weight; and thereon is generally planted Trees of Elm, which are beſt, their Roots being excellent to bind the Earth, and the great Wood will ſerve to make Carriages for Cannons, and the ſmall Branches to make Faſcines. This is what relates to Turf, or Soddwork.

But the Method which is to be obſerved in Maſonry, is quite different for a Wall, whether of Stone or Brick, having need of a very good Foundation, one ought to begin not only as low as the depth of the Ditch, but 3 Feet deeper, thus;

Having to make a Wall of Maſonry, be it of Stone, or Brick, the Foundation muſt be digged 14 or 15 Feet wide; and having digged it 3 Feet lower than ought to be the depth of the Ditch, one muſt examine the Earth, to ſee if it be ſolid enough to ſuſtain ſo great a Maſs of Stone or Brick, and Mortar, which is to be placed on it; for if the Earth is not ſolid enough; it muſt be digged deeper; and in caſe the Earth is Sandy, Marſhy, Boggy, or moving, becauſe of the Tranſpiration of ſome Brook, River, or Spring, *&c.* it muſt be Piled with Piles, or pieces of Timber driven, till they will drive no farther, or at leaſt that a 16 Pound hand Bell-Beetle, will not drive above half an Inch or leſs at a ſtroak, which may be placed near 5 Feet aſunder, filling the Vacancy with Rubbiſh, pieces of Flint-Stones and Earth well rammed or beaten down on all ſides, placing on the Top, well faſtened to each Pile, a Frame of ſtrong Carpenters Grate-Work, made of ſtrong Wood, and moſt proper to endure in the Water, and in the Earth; on this Carpenters-work, covered with thick Planks, muſt be placed 3 Rows of Stone-work, one on the Top of the other, retiring each Row 3 Inches, on which is raiſed in retiring again 3 Inches, the Coat or Wall of new Brick, not too much burn'd, unto the Cordon, or Edge of Stone on the Top of the Rampart, making the Talus the breadth of one Brick in 5, before and behind, building it directly upright.

But if after the Foundation being digged three Feet lower, than the depth of the Ditch, the Ground be found good, fill it with Stones, Flints, and pieces of Old Bricks mix'd with the Mortar, as in ordinary Foundations, obſerving to make two Retreats of 3 Inches each, before, and raiſing the Faces upright; after which muſt be laid the 3 Rows of Stones, of the which we have before ſpoken, each of 15 or 16 Inches for the Bed, and 8 or 10 Inches ſquare, from Joynt to Joynt, mixt at leaſt with a row of Bartiſs or Stones, that go quite croſs, at leaſt of 2 Foot at the ends, the whole placed and well joined together, with a ſmall Joynt of Morter, made of one part of good Lime, and two parts of Sand.

On this laſt Row, muſt be begun in retiring 3 Inches, the Wall of Stone or Brick, with the Talus, as already marked, or one ſixth of the height; ſome ſay one ninth of the height, obſerving to make the Points of the Baſtions of Stones, each of a Foot high, from 15 to 18 Inches in the Bed, from 8 to 10 Inches, from Joynt to Joynt, and of 14 or 15 Inches at the ends, placed ſucceſſively, 3 and 2, on one ſide and the other of the Angles, obſerving to employ two good Boutiſſes in each Row, the one on one ſide of the Angle, and the other on the other, obſerving at the ſame time to make the Counter-forts behind the Coating, which are no other than ordinary Piles of Maſonry, for to hinder the puſhing of the Earth againſt the Coating, which Counterforts muſt have a Foundation as deep as the Coating, and raiſed of the ſame height, and 15 Feet diſtance the one from the other, being 8 Feet long, and 5 Feet broad at the Foot reduced, 3 Feet towards the Top, placed directly upright.

In the ſame time that the Maſonry is a doing, the Ditch muſt be digged by Lays, following the breadth of the Ditch, carrying the Earth thereof, to the Rampart, which muſt be well rammed down, to the end to make a ſolid Body.

But if the Ditch be found full of great Rocks, one muſt make uſe of Leavers, or Crows of Iron of 7 or 8 Feet long, and an Inch and a half thick, pointed at the end, with a ſharp Point like a Nail; then when one works therewith, beat with it in one part of the Rock, without removing from place to place, and break by little and little a hole in the Rock, in which pour a little Water, and it will be found at the end of 7 or 8 Days, that the Leaver will enter into the Rock; then clearing the Hole, with a Line faſtened to the end of a Stick, and fill it with Powder; by firing of which, it will break off pieces of the Rock, which many Horſes cannot tare away: Thus with Pains and Patience, ſuch a Ditch will be digged; the Rubbiſh of which, muſt be carried into the Campaign, beyond the Glacis, and laid in Heaps from place to place, to the end to ſhoot with the Cannon amongſt them, upon the Approach of an Enemy.

The Eſcaipe of the Ditch, muſt alſo be coated with Maſonry and muſt have 6 Feet thickneſs in the Foundation, and 5 Feet and a half above the 2 Retreats, reduced to 3 Feet at the Top.

The ſofteſt Earth of the Ditch, muſt be carried on the Covert-way.

Whilſt the Rampart ſhall be finiſhing to be fill'd with Earth, and the Coating being built on all ſides to the Cordon, or Top of the Rampart, one ſhall place all round a Row of Stone, cut in form of a Round Moulding jetting out half a Foot, which is called the Cordon, above which is built the Parapet, which if made of the ſame matter with the coating of the Rampaat, will endure longer; but it will be much better in time of Service, if it be made of Earth Turfed or Sodded, both without and within, of 4 or 5 Fathoms thick.

Monſieur *St. Julien* would have a Barme left above the Cordon, of 5 or 6 Feet on the Rampart, and there place the Parapet with a Hedge before made of young Plants of White Thorn, planted in a double Row, diſtant a Foot and a half, the one from the other, and the reſt of the ſpace unto the Parapet, to ſerve for a Way quite round to go from one Centinel-

Box to the other, which muſt be placed in each Angle of the Baſtion, and on the middle of the Courtain, which may be of Stone, in form of a Pentagon, with Lamps below jetting out a quarter over the Ditch, whereas all other Authors place the Parapet on the very edge of the Rampart.

I muſt confeſs, tho' this Method of *St. Julien*'s ſeems to me to be altogether new, I at preſent can ſee no reaſon to reject it; ſince beſides the Ornament, and Convenience of the Paſſage aforeſaid, from one Centinel-Box to another, the retiring of the Parapet, give the Soldiers, on the Rampart, a View of an additional part of the Ditch, provided, that it is not retired ſo far as that the Cordon, or edge of the Top of the Rampart, intercept the direct Rays of the Sight, which I think is a thing ſo very plain, that I need not give my ſelf the trouble to demonſtrate it, which has this farther Advantage attending it, that conſequently the Slope of the Top of the Parapet may be leſs; and ſo of neceſſity, the Parapet will become more ſolid, and neceſſarily more capable to reſiſt, or leſs ſubject to be ruined.

As for the *Materials*: The beſt Stone for all theſe kind of Works, are the ſofteſt and eaſieſt to cut; and which has lain in the Froſt all the Winter: The beſt Bricks, are thoſe which are made of White Clay, not too much Burnt; their length is eight or nine Inches, their height is two Inches, and their breadth four Inches: The beſt Mortar is that which is made of the hardeſt Stone, and newly burn'd, fat, and moiſt: The Mixture is one part of Lime, and two parts of Sand, well mix'd together. The beſt Turfs, are thoſe, that are cut in fat Land, which produces the moſt Graſs.

As for what regards the Gates of the Place, they ought to be made in the middle of the Courtain, and the Foundation muſt be made as low as is neceſſary to find a ſolid Bottom, which muſt be filled with the largeſt pieces of Stone or Rubbiſh, and which muſt be levell'd very even near to the Level of the Bottom of the Ditch, on which one raiſes the Bottom of the forepart in Talus, unto the height of the Level of the Ground-Bank, which one terminates by a Cordon, on which one raiſes the Gate of nine Feet, nine Inches broad, and 13 Feet high from the

Threſhold, to the turning of the Arch, or Vault; The beſt are thoſe which are made within, turning to the End, that it cannot be *enfilé*, or ſcowred in a direct Line, by the Cannon of the Enemy, obſerving moreover, to make thereon an Arch, or Vault, and to Earth it on the Top, in ſuch a manner, that a Bomb can have no Effect there, making uſe of the Earth above for a Cavalier, for to Batter in Barbe, the Enemy, and to diſcover the next Baſtions; and of all the Out-works, a Gate of this Nature, is of a great Advantage to the Beſieged.

As for the opening of the Gate, it ought to be ſhut with two double Gates of Oak, barr'd behind, in one of which is a Wicket, or little Door, for to go out, or come in one by one, upon occaſion. Over the Door muſt be hung ſeveral Pieces of Oak Timber, armed with Iron at the Ends; and on the Sides, which are called Orgues, which are better than Horſes, which are made in form of a Grate, which may be ſtop'd by a Waggon, or ſome Piece of Wood below; but the Orgues being made of pieces of Timber hung down ſeparate, cannot be ſtop'd altogether.

The Gate ought to have a Draw-Bridge, which can be drawn up every Night at Sun Set; for it ought not to be intire, for fear leſt the Enemy place his Petards to the Gate, and ruine both it and the Bridge together. The Draw-Bridges of the Gates, as well of the Body of the Place, as the Ravelins, Counterguards, *&c.* are generally made ſtrait, and high in the middle; but ſome are Mad to bend with Barriers, with double folding Doors; on the Sides of which, muſt be Eſtabliſhed as many *Corps de Gards*. The Bridges of the Body of the Place, are generally from 14 to 16 Feet wide.

The *Half-Moons*, *Counterguards*, &c. muſtbe coated and built as the Body of the Place.

As for the *Covert-way*, having made it ſlope a little towards the Ditch, for the Water to run off, its Parapet muſt be raiſed with Turf of ſix or ſeven Feet high, with one or two Banquets for to raiſe the Soldiers. All the Rubbiſh of the Ditch, and all the uſeleſs Ruines muſt be carried behind this Parapet, to make the Glacis or Slope towards the Campaign or Country, which muſt be made as large as poſſible.

Within the *Covert-Way*, muſt be placed all along a Banquet; and the Traverſes, with Paliſadoes of eight Feet and a half in length, and from 18 to 21 Inches Square meaſure; in the middle of which, muſt be pointed with Points of 13 or 14 Inches long, ſo that the Point muſt be in the Center of the Wood: They muſt be diſtant only two Inches, and ſet into the Ground, ſo that they be a Foot higher than the Parapet of the Covert-way, and of the Traverſes, from whence they muſt be diſtant only half a Foot, obſerving to leave Spaces, for the Sallies ſhut with Barriers, with double *Vantaux*, pointed as the reſt of the Paliſadoes.

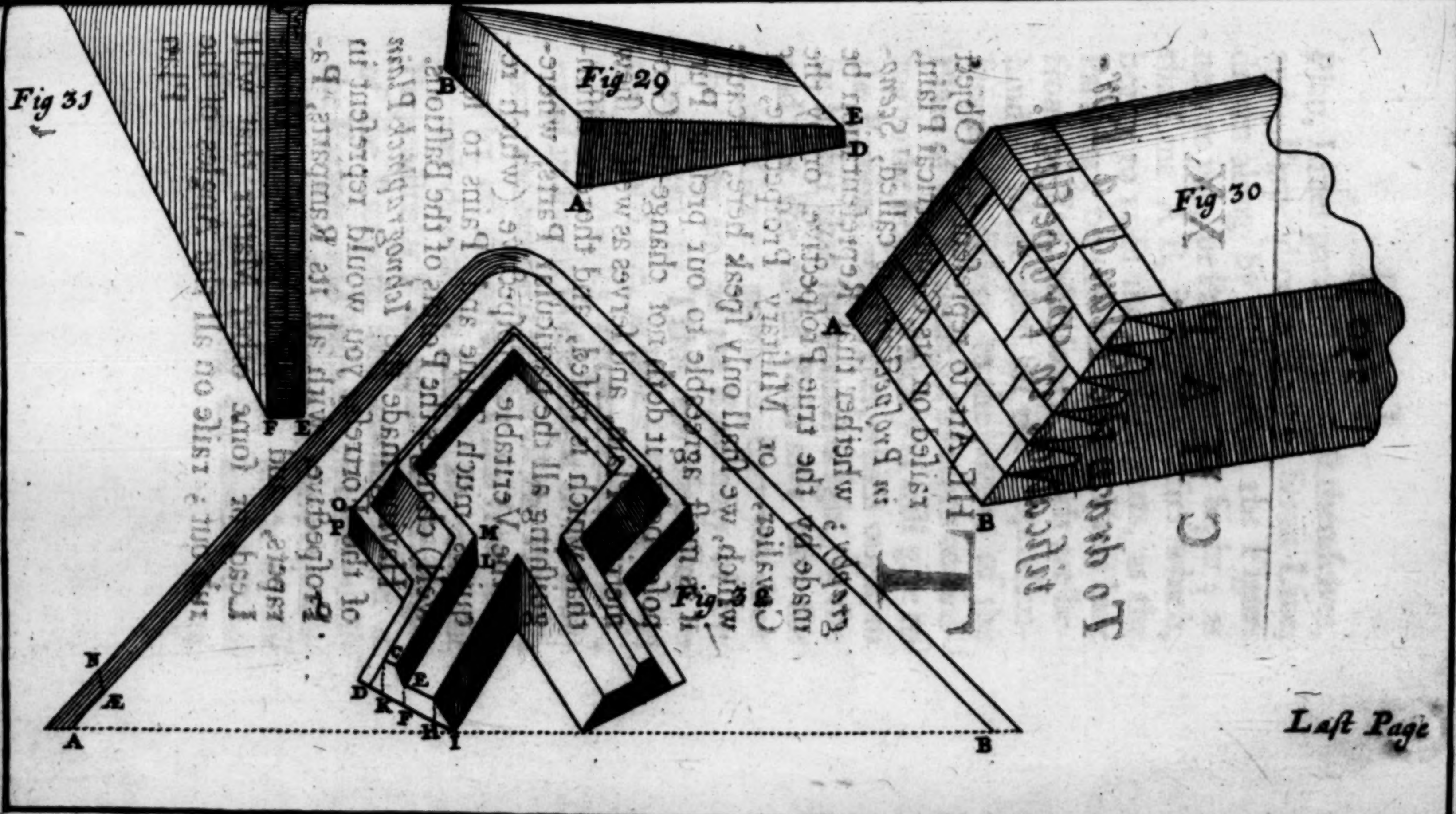
Laſtly, After the Work has been finiſhed three Years, plant on the *Terre-plain* of the Rampart, three Rows of Elm-Trees, which will be very uſeful, as well becauſe of their Roots binding the Earth, as their Branches which cover the Building of the Town, beſide the other Advantages before mentioned.

CHAP. XX.

To draw the Plan of a Fortification in Proſpective.

THE Art to repreſent an Object raiſed on its Geometrical Plain, *in Proſpective*, is called, *Scenography*; whether that Repreſentation be made by the true Proſpective, or by the Cavalier, or Military Proſpective, of which, we ſhall only ſpeak here, becauſe it is moſt agreeable to our preſent Purpoſe, being it doth not change the Geometrical Plain, and ſerves as well to ſhew that which is raiſed, and therein diſtinguiſhing all the particular Parts, whereas the Veritable Proſpective (which requires much Time and Pains to learn well) changes the Points of the Baſtions.

Having made the *Ichnographick Plain* of the Fortreſs, you would repreſent in Proſpective, with all its Ramparts, Parapets, and Out-works, with Black-Lead, or ſome other Matter that will rub out; raiſe on all the Angles of the Plan



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Plan, Lines parallel amongſt themſelves, and Perpendicular to a Strait-Line, drawn along by that part of the Figure next to you, or Parallel to the Sight; as the Line A B, in *Fig.* 32. after which, begin to raiſe the higheſt parts, as the Parapets; becauſe the higheſt Parts hide from the Eye, the lower, which are behind: Make then all the Perpendiculars which belong to the Angles of the Plain of the Rampart, of a length according to the height, which you will give to the Rampart and Parapet, which ought to be higher than its natural height, to the end that the raiſed Plain may have the better Grace; provided, that you draw the lower end of the Extremity of the Out-ſide to the Talus, correſponding to the Right-Line, as here: Having raiſed in all the Angles, Perpendicular, as K C, equal in length to the height of the Rampart, and outward height of the Parapet, and ſet off the outward Talus from K to D, and drawn the Line C D, raiſe the Perpendicular F C, equal to the height of the Rampart, and inward height of the Parapet, and joyn the two Perpendiculars, as at C; then raiſe the Perpendicular H G, equal to the height of the Rampart, and ſet off the inward Talus from H to I, and draw G I; alſo ſet off the height of the Rampart on the Perpendicular F C, from F to E, and joyn the two Points E and G, by the Line E G; having in every Angle after the ſame manner, raiſed and joyned the Perpendiculars of the Parapets, and Ramparts, except ſuch as are hid by the Parapet by Lines, as C M and E L, of the which the height L M, which is equal to the height of the Parapet above the Rampart, ought to be marked within, you will have the Rampart and Parapet finiſhed; then from each Angle of the Barm let fall Lines, as before, Perpendicular to A B, on which ſet off the depth of the Ditch, and place the Talus of the Scarp, as directed, by raiſing the Rampart and Parapet, and joyn the Extremity of the Talus of the Scarp, and the Angle of the Scarp do the like in the Counterſcarp repreſented by N Æ.

Laſtly, From every corner of the Covert-Way, raiſe Lines Perpendicular to A B, equal in length to the height of the Parapet of the Glacis, where, as alſo within the Parapet of the Place, you may, by the ſame Rule, repreſent the Banquets, and conſequently other Works about a Fortreſs.

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